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PROJECT # 8 (95-008)
Traveler Information Services (TIS)

Final Report

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GLOSSARY

API - Application Programming Interface

AVI - Automated Vehicle Identification

AVL - Automated Vehicle Location

BAP - Bearer Application Protocol

BBS - Bulletin Board Service

BIF - Information Format

bps - bits per second

CDPD - Cellular Digital Packetized Data

CTIS - Corridor-wide Traveler Information System

CVO Commercial Vehicle Operations

FDDI - Fiber Distributed Data Interface

FEMA - Federal Emergency Management Agency

FIPS - Federal Information Processing Standard

FOT - Field Operational test

GIS - Geographic Information System

GPS - Global Positioning System

HAR - Highway Advisory Radio

HOV - High Occupancy Vehicle

IEN - Information Exchange Network

ISDN -0 Integrated Services Digital Network

ISP Independent Service Provider

ITIS - International Traveler Information Interchange Standard

NTSC - National Television Standards Committee

NWS - National Weather Service

OMT - Object Modeling Technique

OSF - Open Software Foundation

PCS - Personal Communication System

PDA - Personal Digital Assistant

PSK - Phase Shift Key

RBDS - Radio Broadcast Data System

RDBMS - Relational Database Management System

RISC - Reduced Instruction Set Computer

GLOSSARY- CONT.

SDTS - Spatial Data Transfer Standard

SOC - Statewide Operations Center

SONET - Synchronous Optical Network

TIC - Traveler Information Center

TIS Traveler Information Services or System

TMC - Traffic Management Center

TOC - Traffic Operations center

USGS - U. S. Geological Survey

VAR - Value Added Reseller

VMS - Variable Message Sign

VSAT - Very Small Aperture Terminal

WWW - Worldwide Web

1.0 INTRODUCTION

The I-95 Corridor Coalition's Traveler Information Services (TIS) project is intended to implement an advanced traveler information system tailored to the unique needs of the Northeast Corridor. The system will acquire and disseminate information on roadway traffic conditions, and other pertinent transportation information throughout the Corridor. It will use a variety of static and dynamic information, ranging from transit schedules and call-in reports to real-time traffic monitoring data and transit status information. It will gather, aggregate, and fuse these data in a database architecture that supports dissemination through a variety of communications systems and services to help travelers in the I-95 Corridor choose the most efficient transportation modes and/or routes.

This Project's objectives are:

+ To develop the conceptual system design and define the requirements for a Corridor-wide Traveler Information System (TIS).

+ To identify opportunities and principles for public/private partnering to provide traveler information services.

This report presents the findings of the project work, and is particularly focused upon the conceptual system design. Detailed information supporting the analysis that resulted is provided in the Project's Working Papers. This report is organized according to the following topics:

+ **Define the term "travel information system".** A traveler information system is a decision support system that enables travelers to make intelligent travel decisions at the time and place these decisions are made. This definition is discussed in Section 2.

+ **Develop a "snapshot" of existing traveler information services.** This picture was developed by conducting an inventory of the Corridors existing and planned traveler information services. A summary of these observations is presented in Section 2.

+ **Define goals and objectives for the system to achieve.** These are the goals that individual agencies that make up the Coalition hope to achieve through the implementation of a Corridor-wide Traveler Information System. This vision is described in Section 3.

+ **Define the "look and feel" of the system.** This is a statement of how the system will appear to travelers and the people who operate the system. Section 4 contains this description.

+ **Develop the system's requirements.** These requirements identify what functions the system should perform and serve as metrics to measure the success **of** the system, Section 5 presents the requirements set for the Corridor's Traveler Information System.

+ **Assess the applicability of technology.** The various dissemination technologies that may be used for implementing TIS are discussed in Section 6.

+ **Create the system conceptual design.** Two views of the system are presented in section 7. The first view of the system is the logical architecture-the processes and their connections, The second view is the physical architecture-the allocation of those processes to computers, communications media, and dissemination devices.

+ **Develop a scheme for bringing the system to fruition.** Section 8 is a discussion of potential public/private partnerships necessary for the deployment of the TIS in the Corridor.

+ **Summarize the Project's findings.** Section 9 presents the major findings and results of each Project task.

2.0 DEFINING TRAVELER INFORMATION SERVICES

A Corridor-wide traveler information system (CTIS) supports travelers in making travel decisions. It collects travel data, processes that data into information, and disseminates that information to the people who use it. Clarifying what is meant by a traveler information system is through two different means. The first approach is to define TIS through the well understood ITS America defined User Services. This definition provides an understanding of the functionality that a TIS should provide. The picture is then further clarified by presenting the Corridors existing and planned TIS activities and deployments.

2.1 TIS FUNCTIONALITY

The ITS America defined User Services provides a way for conveniently classifying those functions that are to be provided by TIS. Table 1-1 lists each of these User Services and indicates if the User Service is either:

+ A service that is entirely a TIS application.
+ A Service supported by TIS.
+ A Service that is minimally related to TIS.

2.1.1 Travel and Traffic Management

Pre-Trip Travel Information and **En-route Driver Information** provide travelers with real-time transportation information for making travel decisions where these decisions are made. These services provide information such as traffic conditions, incidents, construction, transit schedules, and other mode choice options as a method for influencing transportation demand. The traveler uses this information for making selections such as mode choice, departure time, and route.

Table 1-1 Applicable ITS User Services for CTIS

Service Category	User Service	TIS Application
Travel and Traffic Management	Pre-Trip Travel Information	TIS Function
	En-route Driver Information	TIS Function
	Route Guidance	TIS Function
	Ride Matching and Reservation	TIS Function
	Traveler Services Information	TIS Function
	Incident Management	TIS Support
	Traffic Demand Management	TIS Support
	Traffic Control	TIS Support
	Emissions Testing and Mitigation	No Application
Public Transportation Management	En-route Transit Information	TIS Function
	Public Transportation Management	TIS Support
	Personalized Public Transit	TIS Support
	Public Travel Security	No Application
Emergency Management	Emergency Notification and Personal Security	TIS Support
	Emergency Vehicle Management	TIS Support
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance	No Application
	Automated Roadside Safety Inspection	No Application
	Commercial Vehicle Administrative Process	No Application
	On-board Safety Monitoring	No Application
	Hazardous Material Incident Response	No Application
	Commercial Fleet Management	TIS Support
Electronic Payment	Electronic Payment Services	TIS Support
Advanced Vehicle Safety Systems	Longitudinal Collision Avoidance	No Application
	Lateral Collision Avoidance	No Application
	Intersection Collision Avoidance	No Application
	Vision Enhancement for Crash Avoidance	No Application
	Safety Readiness	No Application
	Pre-Crash Restraint Deployment	No Application
	Automated Vehicle Operation	No Application

These services require input from the Traffic Control, Incident Management, and Travel Demand Management Services to generate travel information. Both of these services fall entirely within the domain of CTIS.

Route Guidance aids travelers in reaching their destination. This service generates an optimized route based on the traveler-provided origin and destination, current traffic conditions, traveler preferences, and weather conditions. This service also is entirely a CTIS function,

Ride Matching and Reservation has two purposes. First, it reduces the number of single-occupancy vehicles by providing real-time ride-sharing information. Second, it promotes more effective decision making by transportation providers by assisting with vehicle assignment and scheduling. This service is entirely a CTIS function that furnishes information to both travelers and transportation providers.

Traveler Services Information is the frequently described “Yellow Pages” component of intelligent transportation systems. This service provides travel-related information to travelers. **It,** too, is entirely a CTIS function.

Travel Demand Management develops strategic policies for mitigating the unfavorable effects transportation has on the environment and society. Closely related to Travel Demand Management is Traffic Control, it provides the integrated, adaptive control of roadways Traffic Control optimizes traffic flow based on current traffic conditions, weather, and anticipated demand. CTIS is an important partner to both of these services in that it supplies current and future transportation demand information. CTIS also receives information from these services that is required for developing traveler information.

Incident Management minimizes the effect of incidents on the operation of the transportation network by detecting, verifying, and clearing incidents as quickly as possible. Incident Management notifies CTIS of incidents and their current status. CTIS supports the Incident Management User Service by providing capabilities that emergency response vehicles need. Examples of these capabilities include route guidance and en-route driver information.

The user service Emissions Testing and Mitigation measures air quality and develops strategies to mitigate air quality problems related to transportation. Its relationship to TIS is indirect; air quality data are used by Travel Demand Management, which then affects TIS.

2.1.2 Public Transportation Management

En-route Transit Information is primarily real-time information available in public transit vehicles, stops, and transfer points. This service is very similar to En-route Driver Information and will likely share many of the same technologies.

Public Transportation Management provides automated support for monitoring, operating, and planning for public transit systems. It provides transit information, such as schedule adherence, to CTIS for trip planning purposes. It would be useful to Public Transportation Management to receive ridership demand forecasts based on CTIS-generated itineraries. Livery transit services could conceivably plan trips based on CTIS-supplied inputs.

Personalized Public Transit is intended to support travel requirements that cannot be satisfied through traditional fixed-route transportation. The most likely relationship to CTIS is the provision of available capacity. CTIS would then use this information for the purpose of developing itineraries.

2.1.3 Emergency Management

This category is composed of two User Services, **Emergency Notification and Personal Security** and **Emergency Vehicle Management.** Of the two, Emergency Vehicle Management is the more closely related to CTIS. Emergency Vehicle Management provides three major functions, Emergency Fleet Vehicle Management, Route Guidance, and Signal Preemption. The Route Guidance function of this service is likely to use similar algorithms and technologies used for CTIS and Incident Management. The likely variation will be that Signal Preemption information will be used in the development of routes. Emergency Notification and Personal Security is tangentially related to CTIS. It is conceivable that applications such as mayday support may be integrated with the in-vehicle positioning techniques used for in-vehicle route guidance.

2.1.4 Commercial Vehicle Operations

Commercial Fleet Management is composed of the information links needed for transmitting travel information. As such, it will use many CTIS-provided functions.

2.1.5 Electronic Payment and Advanced Vehicle Safety Systems

Electronic Payment could be shared as a currency medium for TIS. The relationship between TIS and Advanced Vehicle Control Systems is that TIS requires information that describes the location of infrastructure support for in-vehicle navigation.

2.2 SUMMARY OF EXISTING AND PLANNED TIS

Most agency-members of the I-95 Corridor Coalition offer some kind of traveler information service. However, most of these services cover a single jurisdiction and a single mode-and often a single dissemination channel, such as highway advisory radio. Indeed, our inventory shows that the Corridor is a patchwork of traveler information services that present the potential user with limited choices and entry modes, and usually requires the user to know which jurisdiction they are in.

Despite the lack of traveler information services in the corridor, two entities in the Corridor stand out as prototypes of the regional traveler information center proposed in our conceptual design:

+ The New York area's Transportation Operations Committee (TRANSCOM), although its original focus was on traffic management, has become a model of multi-jurisdictional, multi-agency cooperation in the collection and dissemination of information relevant to travelers.

+ The Boston area's SmarTraveler service, operated by SmartRoute Systems Inc. in partnership with the Massachusetts Department of Transportation, offers information on highway incidents and transit performance by audiotext and pager.

The most widely used traveler information dissemination mechanism is the telephone. More than 75% of the respondents provide some form of traveler information over the telephone. Information provided over the telephone by departments of transportation and authorities includes construction summaries, real-time incidents or congestion, and road-related weather conditions. Information provided by other agencies include static schedule, route, and fare data.

3.0 AGENCIES' GOALS

During Task 2-TIS Goals Definition-a candidate set of goals and objectives for traveler information services in the l-95 Corridor was developed. These goals and objectives are shown in Table 3-1. Each of the Coalition member agencies was then asked to rank the information dissemination devices they used today and that they thought they would use in each of three future timeframes, as shown in Table 3-2.

Table 3-1: Overall Goals and Objectives of Traveler Information Services

Goals	*Objectives*	*Rank*
1. To make available timely, accurate multimodal information on traffic and travel conditions in the Corridor to both private travelers and commercial operators of both passenger and freight transportation services.	1. To provide traffic and other travel information to any point in the Corridor about any point in the Corridor or about facilities between any two points in the Corridor.	High
	2. To support just-in-time delivery by providing usable and actionable information on the state of the transportation network, thus enabling just-in-time shippers to adjust their operations to reduce cost yet make deliveries.	Med
	3. To reduce stress associated with travel in unfamiliar or congested areas by providing routing and other information to travelers new to an area in the Corridor.	Low
	4. To promote the Corridor Traveler Information Services system and induce its use by providing information to the public via public relations and advertisements of TIS services, access methods, and locations utilizing signage (electronic, fixed), radio, TV, newspapers, etc.	High

Table 3-1: Overall Goals and Objectives of Traveler Information Services - Cont.

Goals	***Objectives***	***Rank***
2. To shift highway travel to non-highway modes by giving travelers information on modes that may get them to their destination faster, cheaper, more safely, or more comfortably.	1. To maintain and disseminate real-time and non-real-time information on travel conditions, by other modes, in the Corridor.	High
	2. To integrate effectively information about other modes, particularly air and rail information, with operational information on the highway system.	Med
	3. To provide usable and actionable information on non-highway modes, particularly to route travelers around congestion.	Med
	4. To improve multimodal and intermodal transportation operations by providing information on, e.g., link travel times for transit time-of-arrival estimates, park-and-ride lot status, and passenger-loading estimates.	Med
3. To coordinate the management of facilities and the collection and delivery of traffic and other travel information across jurisdictional and modal boundaries, and to render such boundaries (particularly jurisdictional boundaries) transparent to the traveler.	1. To develop new modes of cooperation that facilitate, even effect, the striving toward goals common to all agencies in the Corridor involved in Traveler information Services.	High
	2. To monitor and help coordinate Traveler Information Services and systems operated and maintained by individual states, local authorities, and local agencies.	High
	3. To receive regular communications on current and anticipated traffic and other travel conditions on major facilities from all transportation agencies in the Corridor.	High
	4. To establish a “clearinghouse”, virtual or real, to coordinate the collection and delivery of traffic and other travel information in the Corridor on a real-time basis.	High

Table 3-1: Overall Goals and Objectives of Traveler Information Services - Cont.

Goals	*Objectives*	*Rank*
4. To support management of highway traffic in the Corridor.	1. To assist transportation agencies in the Corridor to manage non-recurring incidents that disrupt the transportation system by advising travelers of the delay and recommending that they revise their travel plans.	Med
	2. To enhance real-time traffic control operations by providing information on, e.g., HOV facilities, reversible lanes, and congestion pricing.	Low
	3. To enhance traffic management during snow storms and other emergencies by providing information on, e.g., snow removal scheduling & operations.	Low
	4. To reduce disruptions caused by traffic incidents by quickly sending to motorists information about the incidents and how to avoid them.	Low
5. To gain and increase the private sector's participation in the design, development, operation, maintenance, and enhancement of the Corridor Traveler Information Service and system.	1. To develop new modes of cooperation, communication, and coordination between the public sector and the private-sector entities participating in Traveler Information Services.	High
	2. To gain private-sector stakeholders' buy-in to the traveler information system's requirements and design.	Med
	3. To supplement public funding of the Corridor Traveler Information Services system by organizing revenue-generation schemes, such as the sale of traveler information to private-sector entities for resale, redistribution, or other added-value reuse, or through fees, royalties, and similar payments from private-sector entities wanting their products or services advertised or promoted through the Corridor Traveler Information Services system.	High
	4. To privatize appropriate portions or functions of the Corridor Traveler Information Services system.	Med
6. improve corridor environmental air quality	1. Reduce air pollution (attainment of carbon monoxide, nitrous oxide, patticulates) by minimizing peak period congestion.	High
	2. Reduce air pollution by encouraging carpooling.	High
	3. Reduce air pollution by increasing transit ridership and increasing the ease of transfers between modes.	High
	4. Reduce air pollution by providing TIS to influence route, mode or travel time changes.	High

Table 3-2: Current and Planned TIS Dissemination Devices

TIS output device	*Current*	*'95-96*	*'97-99*	**2000+**
a. Variable Message Sign (VMS)	65%	**77%**	*95%*	**95%**
b. Highway Advisory Radio (HAR)	54%	**77%**	**82%**	**82%**
c. CB/Amateur Radio	12%	**23%**	**23%**	**27%**
d. In-Vehicle Monitors/Displays	4%	**18%**	**32%**	**59%**
e. Faxes	38%	**45%**	**45%**	**49%**
f. Pagers	12%	**23%**	**32%**	**36%**
g. Public Kiosks	19%	**50%**	**64%**	**68%**
h. Cable or Regular TV using Images	15%	**31%**	**45%**	**50%**
i. Cable or Regular TV using Teletext	4%	**31%**	**45%**	**50%**
j. Interfaces to Public (Commercial) Radio Stations	35%	**50%**	**55%**	**55%**
k. Hand-Held Devices or Lap Top Computers	0%	**23%**	**27%**	**45%**
l. Telephone access using Phone Menus (Press 1 to hear traffic, ...)	69%	**83%**	**89%**	**93%**
m. Dial-In Computer Bulletin Boards (e.g. Prodigy, America Online)	8%	**41 %**	**50%**	**55%**
n. Internet Accessed Information (e.g. Mosaic)	0%	**32%**	**45%**	**50%**
o. Commercial Traffic Reporting Agencies (Metro or Shadow Traffic)	38%	**64%**	**68%**	**68%**

4.0 THE CTIS VISION

During Task 3--Requirements Analysis-we sketched a "vision" of the Corridor-wide Traveler Information System, which this section summarizes. This vision is seen from the perspectives of an end user and an operational user.

4.1 END-USER VIEW

The end user view of CTIS makes assumptions about the features that are essential to the success of advanced traveler information systems in the foreseeable future. These assumptions are:

+ Data collection for the Corridor-wide Traveler Information System (CTIS) can be based on static and real-time data collected from public agencies, but will need to be augmented by privately collected quantitative and qualitative data for roads and transit routes not covered by automated public-agency systems (due to existing gaps in surveillance, as discussed in Project 3's Final Report). The intensity and completeness of public-agency data are uneven throughout the I-95 Corridor. Operating experience with working traveler information services makes clear that detailed, up-to-the-minute event data are the first essential building block to generating usage of an advanced traveler information system.

+ Data collected from public and private sources for integration into CTIS will be "fused" and maintained in one or more regional traveler information centers (RTIC), in which the data will be interpreted and formatted for use in CTIS dissemination media.

This end-user view presumes that the I-95 Corridor-wide Traveler Information Service will evolve over a period of years, going through three identifiable stages, each with its level of technology, relationship between public and private funding, and level of traveler behavior modification and interjurisdictional collaboration.

4.1.1 Phase I: Baseline Information Dissemination (0-2 years)

Phase I of CTIS is focused on rapidly deployable, baseline information dissemination to the broadest possible public, at little or no charge. In addition, through its comprehensive data collection system and database management, the Phase I system is capable of rapid communication about incidents and traffic and transit trends to all affected public agencies, playing a critical role in enhanced incident management. Distinguishing characteristics of the Phase I system are:

+ Baseline Information Dissemination:

- Designed to accomplish near-term public-policy objectives by reducing congestion and vehicle emissions, increasing mobility, and enhancing public safety.
- Designed to build confidence in potential users and public-policy decision-makers.
- Based on proven, tested and evaluated technologies.
- Designed to modify traveler behavior so that they learn to use traveler information systems in general, CTIS in particular.
- Relies heavily on telephony (both wireline and cellular), as the telephone remains the most ubiquitous communications medium with a real-time interactive capacity. In addition, other existing, low-risk, proven technology are likely to be employed, including the use of dial-in bulletin boards, faxes, and pagers.
- Aggressively multimodal to encourage modal shifts.
- Subsidized substantially by the public sector, as private-sector investment and consumer dollars will not be drawn to low-cost dissemination nor to promotion of multimodality and environmentally constructive travel.
- Includes information that serves key functional areas, including mode choice, route choice, and early stage “real-time” rerouting.

- Includes high priority information elements identified above, at least in their early stages-real-time traffic conditions and incidents, construction activities, special events, weather conditions, and, where available, information on transit conditions and schedules, multimodal options and travel-time comparisons, traveler and tourist facilities, traffic diversion and speed advisories, and emergency services.

+ Incident Management Support:

  - Designed to enhance the traffic recovery function, by broad dissemination of advice to avoid incidents, and of advice that incidents are cleared.

  - Includes emergency notification via pager of all key public-agency personnel.

  - Includes comprehensive database compilation of incident management data, including incident occurrences, traffic impacts, clearance times, etc., for congestion management reports required by the Federal Highway Administration.

End users, in the broad categories of individual travelers and public agencies, will have ready real-time access to the information and services described above from the Phase I CTIS. In addition, we assume that commercial vehicle operators will continue to develop their own systems, since the operators derive direct economic benefit from real-time traveler information. We further presume that the commercial vehicle operators will access the Phase I CTIS to enhance their own systems, perhaps for a fee paid to the operator of the CTIS; and that the commercial end user of traditional radio and TV stations (and their customers, the traveling public) will make use of this enhanced traveler information database to deliver more accurate radio and television traffic reports, and that the radio traffic reports will continue to be a critical component of the traveler information system, since radios will continue to be the principal in-vehicle communications device.

4.1.2 Phase II: Multimedia, Interactive Information Dissemination (2-5 years)

Phase II of the Corridor-wide TIS looks significantly different to the end user. Induced in part by the widespread dissemination and use of baseline information in Phase I, more sophisticated private-sector information dissemination media proliferates. Trained by the public sector's aggressive promotion of the baseline system in Phase I, the traveling public sees increasing value in the purchase and use of more sophisticated traveler information services, delivered over private media at the expense of either the individual consumer or the wholesaler (such as paging companies or cable-TV operators) who see their media enhanced by the delivery of advanced traveler information. The individual traveler-end user begins to see in Phase II the availability of interactive multimedia traveler information services over telephone, TV, on-line services, personal digital assistants (PDAs), etc. In addition to the baseline information disseminated in Phase I, Phase II begins to see new, more sophisticated kinds of information, including predictions and estimation of traffic conditions; traffic demand patterns and trends; detailed, dynamic trip planning and routing information and guidance; and dynamic multimodal trip planning and connectivity. It is anticipated that these new multimedia, interactive information dissemination media offered by the private sector to individual travelers and fleet operators will make extensive use of the traveler information database maintained by the CTIS, perhaps at a fee, which could reduce the level of public subsidy. In addition, dispatchers and fleet managers will begin to be able to make use of similar interactive multimedia information dissemination devices serviced by CTIS.

Public-agency end users in Phase II expand the deployment and sophistication of on-road demand management devices such as variable message signs, highway advisory radio, and possibly highly visible kiosks in public place (such as parking garages, shopping malls, rest stops, intermodal transfer points, and other public locations).

4.1.3 Phase III: Real-time, In-vehicle Information Dissemination (5-10 years)

In Phase III, heavy emphasis in CTIS shifts to widespread deployment of in-vehicle navigational devices displaying real-time, multimodal navigational information. Such in-vehicle devices likely also serve as mobile probes, recording real-time traffic conditions on an anonymous basis back to CTIS, providing CTIS (which also services real-time on-road dissemination media such as variable message signs and highway advisory radio) with largely automated, quantitative real-time data. Optimal pre-trip planning, which has the ability to have maximum impact on route, time, and mode of travel, is serviced through increasingly sophisticated multimedia interactive devices in the home or office. But the preponderance of consumer expenditures and commercial-vehicle end-user expenditures will flow to in-vehicle navigational devices and their servicing with real-time information.

4.2 OPERATIONAL-USER VIEW

Just as the view of the end user will change over time as the Corridor-wide Traveler Information System develops, so too will the perspective of those operating the regional traffic operations centers. For this operational user's perspective, the same three-phase developments of CTIS is contemplated.

4.2.1 Phase I: Baseline information dissemination (0-2 years)

The operator in the regional traveler information center receives and coordinates many disparate pieces of information about travel conditions within the center's region. The operator communicates with local traffic operations centers within the region and control centers for bus, rail, air, subway, and ferry services. In addition, the operator collects information from commercial traffic reporting services, and possibly commercial vehicle operations to help fill the gaps in public agencies' information. The data acquisition and fusion process initially is likely to be a manually intensive task. As the system evolves, however, more automated interfaces will be developed to exchange information with public and private data sources. This effort must be performed in concert with the Project l-Information Exchange Network-and Project 3-Surveillance Requirements & Technology.

Finally, the operator collects information from other entities, such as the regional weather services, whenever necessary. The RTIC then fuses and formats the data, and disseminates useful information to the wholesalers of traveler information. This data fusion and formatting step may be a public or private enterprise, while dissemination is almost certainly a private function (except for dissemination through variable message signs and highway advisory radio).

The operator also communicates information to public agencies within the Corridor, such as incident information to agencies responsible for clearance, and real-time traffic information to transit agencies for improved operational management of their services.

4.2.2 Phase II - Multimedia, Interactive Information Dissemination (2-5 years)

During Phase II of CTIS' evolution, the operator's view from the RTIC does not differ greatly from Phase I. He or she still receives information from multiple, disparate sources and fuses those data for use as they come in. As more and more public-sector traffic operations centers come on line, the operator may have less need for reliance on information from commercial vehicle operations for filling the information gaps, but will still rely on private-sector entities for some information gathering. In addition more automated interfaces will be developed to existing traffic operations centers to reduce the manually intensive data acquisition and fusion tasks.

The big changes in Phase II are in the dissemination media. The operator feeds the collected information to a much more sophisticated network of dissemination devices. The RTIC operator also does more with the collected information to enhance its value. The RTIC database is used in predictive as well as descriptive ways.

As the sophistication of the dissemination media increases, so too does the complexity of the operator's daily routine. In Phase I, for instance, the operator may deal with one type of dissemination-e.g., an audiotext system-while Phase II has more varied and complex systems.

4.2.3 Phase III: Real-time, In-vehicle Information Dissemination (5-10 years)

This longer timeframe promises the greatest changes for the operational user. Technologies for data collection are shifting from road-based to vehicle-based systems. For instance, a current field operational test in the Washington, D.C., area is assessing the viability of measuring traffic speeds and link times by tracking cellular telephones. Also, as mentioned above, the proliferation of in-vehicle devices may provide another means of automated data collection based on the vehicle.

While this shift radically changes the role of the operator in data collection, perhaps transforming her or him from an active participant in data collection to an interested overseer of an automated data collection system, it does not have similar effects on the fusion and dissemination elements.

Indeed, while in-vehicle devices for tracking traffic condition hold substantial potential for improving the quality and quantity of data collected in the TIC, they further complicate the fusion and dissemination elements by introducing additional dissemination outputs to serve these devices.

5.0 REQUIREMENTS

Using the Corridor's TIS goals and objectives, in conjunction with the CTIS vision, requirements for the system were derived. These requirements are organized under the following categories:

+ User Requirements - these are the system's functional requirements.
+ Communications Requirements - the requirements that describe the necessary communications networks.
+ Database Requirements - these requirements state how data within the system shall be organized, stored, and accessed.
+ Interface requirements - detail the interactions with external entities.
+ System-level requirements - describe the system's technical requirements.

5.1 USER REQUIREMENTS

One of the main thrusts of the requirements analysis process was to develop the information needs of travelers in the Corridor-the user requirements aspect of the I-95 Corridor-wide Traveler Information System. To analyze these requirements, we assessed three dimensions:

+ Types of users.
+ Their needs.
+ The full range of delivery possibilities.

During Task 2-Define TIS Goals-we developed Specific User-Service Goals, as shown in Table 5-1. Each of the candidate objectives identified there can be thought of as a highest-level user requirement.

5.1.1 Types of Users

During Task 3, the following principal classes and subclasses of users of a Corridor-wide Traveler Information System were identified:

+ Travelers.
+ Employers.
+ Special-event generators.
+ Operators of public places.
+ Operating agencies.
+ Emergency services.
+ Private-sector disseminators.

Travelers are the largest and most important component of CTIS' end users. To be able to test the requirements against this very large group of users, travelers were further divided according to both their *purpose* and the *distance* in which they travel.

For the analysis, four distances for travelers were defined:

+ intraurban;
+ suburb-to-city;
+ intersuburban; and
+ interurban.

For the analysis, purposes for a traveler are:

+ commuters;

+ business;

+ goods carriers, fixed- or variable-route: and

+ tourists.

5.1.2 User Needs

User needs were derived from two sources: user services we developed in Task 1 and prioritized in Task 2, and from developed scenarios.

We took the User Services identified in Task 1 and ranked them according to how the Corridor' s transportation agencies viewed their importance. This is shown in Table 5-1.

Table 5-1: Ranked User Service Goals and Objectives

Candidate Goals-Ranked	*Candidate Objectives--Ranked*
1. Enhance urban and interurban corridor road travel for various roadway users: - business travelers - tourists - commuters - CVO/dispatchers - transit/paratransit operators	Provide timely and accurate information on the following, to both pretrip (home, workplace, transit stops, rest stops, public locations, etc.) and enroute (in-vehicle) users: 1. Real-time incident/congestion summaries. 2. Traveler advisories. 3. Road weather conditions. 4. Construction summaries. 5. Alternate routes and modes. 6. Real-time link status. 7. Route guidance information. 8. Parking availability. 9. Parking locations. 10. Intermodal transfer points. 11. Trip planning capability. 12. Road environmental conditions.

Table 5-1: Ranked User Service Goals and Objectives - cont.

Candidate Goals-Ranked	*Candidate Objectives--Ranked*
2. Enhance modal and intermodal travel for various urban and intercity mass transit users: . Bus, Subway Travelers • Air Travelers • Rail Travelers • Ferry Travelers	Provide timely and accurate information on the following, to both pretrip and enroute users: 1. Schedule, route, and fare information on all transit modes (bus, train, subway air, ferry). 2. Real-time status location information On transit modes (bus, train, air, subway, ferry). 3. Paratransit services. 4. Ride-matching services. 5. Trip plans. 6. Modal travel time comparisons.
3. Enhance the safety of travelers	Provide timely and accurate information on the following, to both pretrip and enroute users: 1. Locations of hospitals. 2. Locations of emergency telephones. 3. Locations of repair shops. 4. Locations of police.
4. Increase the availability of traveler information	Provide timely and accurate information on the following, to both pretrip and enroute users: 1. Regional weather conditions. 2. Food/dining and gas information. 3. Lodging. 4. Regional environmental conditions.
5. Increase tourism	Provide timely and accurate information on the following, to both pretrip and enroute users: 1. Special events. 2. Attractions. 3. Historic sites. 4. Festivals. 5. Parks and recreational facilities. 6. Cultural and arts activities. 7. Educational institutions 8. Resorts.

5.1.3 Delivery

Information may be delivered to the traveler in many different ways. This section, identifies what information may be delivered to travelers, and how travelers' needs are affected by how the information is delivered. Methods for delivering data are classified by where and how, each of which is discussed further below. What you will not find is the technology. For example, en-route personalized delivery may be over subcarrier, cellular telephone, pager, or a new radio channel, but it does not matter in this document for two reasons:

+ Dissemination technology is largely irrelevant to the information and functional needs of the user.

+ Dissemination technology is more the property of operating agencies or private-sector disseminators than of CTIS itself.

In our analysis, traveler information can be delivered in any of three places:

+ en route

+ at home or office.

+ in a public place.

In our analysis, traveler information can be delivered in one of three ways:

+ personalized.

+ specialized.

+ broadcast.

5.2 COMMUNICATIONS REQUIREMENTS

The Corridor-wide Traveler Information System requires a robust communications system to move data from center to center and to get timely and accurate traveler information to all types of pretrip and en-route users (e.g., commuters, business travelers, commercial vehicle operators, private-sector disseminators, and so on).

The capabilities identified in the requirements document for Project l-Information Exchange Network-will support the movement of video, voice, and data from center-to-center. The IEN, however, does not handle center-to-dissemination devices or center-to-private sector disseminators. To insure consistency in the Corridor's infrastructure the TIS requirements and design reflect the capabilities of the IEN in a consistent manner.

The operational requirements used in the defining the CTIS communication links are based on a flexible, adaptable, communications system which maintains a capability for long term growth.

Flexibility, as defined here, is the ability for the communication system to accommodate different communication standards without compromising the data flow of the system. The CTIS communication subsystem shall be flexible so that a mixture of communications techniques may be used in the distribution and dissemination of data.

Communication standards shall be fully compatible with the existing de *facto* or emerging standards where possible.

At a minimum, CTIS communications shall be compatible with the communication standards shown in Table 5-2.

To maintain flexibility, incompatible data formats are to be avoided when using a common media. The CTIS communications network shall preclude the use of a proprietary communication protocol which excludes the use of other communications protocols sharing the same transmitting media. Subnetworks using a particular communications protocol exclusively are allowed. However, if the data is to be shared on a broadband network, a communications gateway shall be used to convert the protocol to the broadband media-compatible protocol.

Table 5-2 CTIS Communication Standards

RS232	SONET-Synchronous Optical Network
HDLC	FDDI-Fiber Distribution Data Interface
RS449	ISDN-Integrated Services Digital Network
RS485	ATM-Asynchronous Transfer Mode
NTSC Analog Video	H.261 Compressed Video
FM and PSK Radio	Cellular Radio
RS422	Ethernet (IEEE 802.3)
DS1	VSAT
RS530	X.25 Data Packetizing
TCP/IP	CSMA, CSMA/CD
CDPD	FM-SCA

The first issue of adaptability is the ability of the communication system to accommodate unique jurisdictional requirements while being technologically contemporary. This implies that critical data services through the network shall not be interrupted due to the addition of these new equipment or changes in system topologies.

The second issue of adaptability is the CTIS communication system's compatibility with the needs of the local TICs (public or private). This allows for the differences in requirements for each local TIC. These differences may include the types and amount data (voice, image, data), and the available resources.

The long-term growth of the CTIS communications environment is based on the factor of adaptability, flexibility, and scaleability. Provisions, therefore, shall be made within the communications link budget to accommodate future systems as they become available. Examples include future or planned TMCs, TICs, road weather and environmental systems, regional weather and environmental systems, and AVI/AVL and cellular tracking systems.

5.2.3 Communications Alternatives

There are a variety of options available for the center-to-center and center-to-dissemination device communication links. These include both wire and wireless options as shown below:

Wire	*Wireless*
Twisted pair cable	Microwave
Coaxial cable	Spread spectrum radio
Fiber optic	CDPD
Leased lines	AM/FM Subcarrier
Public lines	Radio Paging
	TV Subcarrier

5.3 DATABASE REQUIREMENTS

The CTIS database maintains the traveler information collected, fused, and disseminated by CTIS. Two classes of data are considered the primary responsibility of the CTIS database:

+ General alphanumeric structured data (including text fields).

+ Map/geo-referenced data.

The increase in the quantity, type, and complexity of data will require the integration of sophisticated, reliable, and mature technologies. The database requirements for CTIS address the techniques and technologies required to manage the information.

5.3.1 General Database Requirements

The CTIS database plays a fundamental role in achieving the CTIS goals and objectives. The CTIS database must receive, fuse, and validate data efficiently and accurately. Timely, accurate multimodal information on traffic and travel conditions in the Corridor must be made available to both private travelers and commercial operators of passenger and freight transportation services. Highway traffic data relating to non-recurring incidents will be maintained by the CTIS database and automatically distributed to the appropriate transportation agencies within the Corridor. The database is also responsible for maintaining transit information in order to assist a traveler in choosing the most efficient mode(s) of transportation.

5.3.2 Map/Geo-Referenced Database Requirements

The dissemination of information to travelers in support of multimodal regional and interregional travel will depend on the ability to associate the data to a specific geographic location within the I-95 Corridor. The communication of data such as trip plan alternatives, traffic and transit conditions, parking data, environmental and weather data, special event and tourism information, and traffic diversions are facilitated by tools and capabilities available from commercial off-the-shelf map products and geographic information systems (GIS). Several GIS products include network analyses and routing algorithms.

5.4 INTERFACE REQUIREMENTS

The system-level requirements addressed here examine the exchange of information with both existing and future systems that support traveler information services within the Corridor.

5.4.1 Traffic Operations Centers

A primary source of CTIS data will be from traffic operations centers located throughout the I-95 Corridor. These centers will all supply data over the Information Exchange Network (IEN), which is to network together the local and regional systems with CTIS, creating a seamless mechanism for exchanging travel data within the Corridor.

The local and regional systems will gather local and regional information respectively, such as: real-time traffic and road information, incident data and logs, event plans and status, and static network data. This predominately real-time information will be provided to CTIS, which will, in turn, supply the local and regional systems with traffic demand and trends information.

5.4.2 Transit Dispatch Centers

Public and private transit dispatch centers will be the primary provider of transit related information to CTIS. Transit dispatch centers will gather data and information for bus, rail, air, subway, and ferry. Typical information available at a transit dispatch center would include real-time transit information, static transit data, and traffic demands and trends. CTIS will then supply the transit dispatch centers with updates to the projected demands and trends, based on actual public user information and the real-time transit information. Therefore, CTIS and the transit dispatch centers will work in accord to achieve maximum efficiency when exchanging transit related information. When applicable, information exchanged between these two systems will use the IEN.

5.4.3 Non-Corridor Traffic Information Centers

Non-Corridor traffic information centers (TICs) do not lie within the geographic boundaries of the I-95 Corridor. For example, a non-Corridor TIC could be in Raleigh, North Carolina. These non-Corridor TICs will have an interface to exchange interregional TIC information with CTIS. The IEN will not be the mechanism for exchanging data with non-Corridor systems.

5.4.4 Commercial Traffic Reporting Firms

Commercial traffic reporting firms will be another source of relevant information for CTIS. Metro Traffic, Shadow Traffic, Traffic Net, SmarTraveler, and Traffax are all examples of the increasing presence of commercial traffic reporting firms. Although the actual operations of the firms vary substantially, the information required by CTIS is consistent: real-time traffic information, incident data and logs, and event plans and status. Interfaces with these commercial traffic reporting firms could potentially use the IEN.

5.4.5 External Databases

External databases will be another source of data for CTIS. There are several types of databases that will maintain information relevant to CTIS. Typical information expected to be available from external databases includes weather and environmental information, parking data, fleet probe data, and geographic data.

5.4.6 Private-Sector Disseminators

Private-sector disseminators will exchange data with the Corridor TIS on an as-needed basis. In general, the private-sector disseminators may have their own subscribers, and may wish to augment their own information with information available from the Corridor TIS. The Corridor TIS will have provisions to accept information requests from and send access grants and requested data to the private disseminators. In addition, the Corridor TIS may receive value-added data from the private disseminators.

Private sector disseminators encompass many ranges of information disseminators. Typical examples include information service providers, communication service providers, value-added resellers, hardware and software providers, media (TV, radio, print), commercial traffic firms, and employers. These private disseminators would each have unique information needs and therefore would request relevant data as needed from CTIS.

5.5 SYSTEM-LEVEL REQUIREMENTS

The system-level requirements are those requirements that are applicable to the system as a whole, to which each subsystem shall be compliant.

System-level requirements are defined for the following categories:

+ hardware.
+ software.
+ fault tolerance.
+ performance.

5.5.1 System-Level Hardware Requirements

It is important to recognize that the actual number of workstations, communication links, and the characteristics of the hardware in general are subject to change based on the following:

+ Size of the traffic network (surveillance and control scope).
+ System performance requirements.
+ Functional specifications.
+ Customer/site requirements (external interfaces, type and quantity of incoming and outgoing data at each site-e.g., data to commercial traffic reporting firms, required staffing profiles).
+ Size of the region (e.g., number of participating nodes, communication load requirements).
+ Technological advances (e.g., hardware performance).
+ Deployment considerations:
    - Characteristics/configuration of existing system.
    - Upgrade/migration path.

- Policies and procedures.
- Budgets.
- Available space.

5.5.2 System-Level Software Requirements

The system-level requirements for the software are driven by the need to:

+ Execute applications on any vendor’ s platform (hardware independence).
+ Produce a maintainable and modular system.

The CTIS software must be modular, maintainable, and flexible so that it is adaptable and flexible to accommodate new technologies as they become available.

5.5.3 Fault Tolerance Requirements

The fault tolerance requirements for the CTIS reflect the need for a system that is highly reliable and available. To meet this need the system must be designed such that there is no single point of failure within the system, meaning that there must be adequate redundancy in the system hardware and software. This entails an implementation that is easily reconfigurable within 5 minutes of any failure.

5.5.4 Performance Reauirements

The system shall provide sufficient CPU, memory, disk, and network resources to simultaneously accomplish the following types of activities without severe degradation of system performance or response times. The system shall not use more than 75 percent of its primary resources (CPU, Disk, Memory, I/O Network) during normal operations: and not more than 90 percent during emergency situations. A subsequent analysis of primary functions versus demand on primary system resources will be necessary on a subsystem-by-subsystem basis. User input via a keyboard or mouse should be accepted (not necessarily responded to) within 2 seconds. The update of displays for real-time data shall occur at user-definable intervals with a minimum resolution of twice per second, accurate to 1/10 of a second.

5.5.4 System-Level Operator Interface Requirements

The system-level operator interface requirements are driven by the needs to:

+ Establish a common, consistent interface between users and applications to reduce training and increase operator productivity and performance.

+ Limit modifications to operator interface code when porting to a new hardware platform by adopting a common applications programming interface (API) that is stable for all or many platforms.

The interface between the operator and applications is important since it provides the framework for interactions necessary for the effective and efficient operation of the system.

6.0 APPLICABLE TECHNOLOGY

As intelligent transportation systems evolve, new methods of collecting, fusing, and disseminating data are proliferating, and the future promises much more of the same. With these uncertainties, our approach focuses on both currently available technologies and emerging technologies. For consistency, this evaluation separately identifies and assesses technologies for data management and data dissemination,

6.1 DATA DISSEMINATION TECHNOLOGY EVALUATION

Each dissemination technology is evaluated according to its performance against these criteria:

+ Ability to meet user needs.
+ Accessibility (how readily available is the technology?).
+ Interactivity (what capabilities does the device have that support users requesting specific information?).
+ Cost of implementation (how expensive is it for the disseminator to implement the technology?).
+ Cost to user (how expensive is it for the user to obtain the technology?).
+ Ease of use.

Table 6-1 summarizes the evaluation of the various dissemination methods.

Table 6-1. End-User Device Technology Evaluation

Device	Priority 1 Accessibility	Priority 2 Ability to Meet User Needs	Priority 3 Interactivity	Priority 4 cost of Implementation	Priority 5 Cost to User	Priority 6 Ease of Use
Radio	High	Medium	Low	High	High	High
Television	High	Medium	Low (unless interactive)	Medium	High	High
Telephone	High	High	High	Medium	High	High
Pagers	Medium	Medium	Low	Medium	High	High
In-Vehicle Devices	Low	High	High	Low	Low	Medium
Kiosks	Medium	High	High	High	Medium	High
Computers and PDAs	Medium	High	High	High	Medium	Medium
Faxing	Medium	High	Low	High	Medium	High
VMS	Medium	Medium	Low	High	High	High

High = meets all criteria Medium . partially meets cntena Low = does not meet criteria

6.2 DATA MANAGEMENT TECHNOLOGY EVALUATION

In order to preserve current investments in technologies throughout the I-95 corridor and ensure system scalability and portability, Commercial-Off-The-Shelf (COTS) database management systems will form the foundation of the CTIS. COTS products facilitate lower development costs through the reduction in the amount of custom software. As a result, development time is minimized. Selecting COTS products which may operate on a variety of hardware platforms will ensure system scalability and portability.

There are two modern models of database management systems (DBMS), Relational Database Management Systems (RDBMS) and Object-Oriented Database Management Systems (OODBMS). Each of these DBMS derives its name from the method that data in the system is represented.

The data representation model in a RDBMS relies on data being stored in two-dimensional tables, each of these tables is known as a relation. The columns of an individual table are the attributes of the relations and the rows represent the elements that are related. If two tables (relations) contain a common column (attribute) then it is capable of relating a piece of information stored in a table to information contained in another table.

There are three important elements in an Object-oriented system, classes, messages, and objects. A class is a representation of real-world entities. It represents the entities composition, behavior, and interfaces with other entities. An object is an instance of a class and objects communicate through messages. One of the major advantages of object-oriented systems is the notion of inheritance, new classes can be created by extending, modifying, and mixing classes.

The decision as to which type of database management system (relational or object oriented) should be selected will depend on the products ability to fulfill the CTIS database requirements identified in Task 3. An important consideration to ensure the system's ability to interoperate with a diverse set of applications and systems is the utilization of a standard Data Definition Language (DDL) and Data Manipulation Language (DML). Currently, a standard for OODBMS has not been established. Structured Query Language (SQL) is the standard language used by RDBMS. Since RDBMSs have been in existence longer than OODBMSs, RDBMS technology is more mature. This provides two distinct advantage:

+ Relational database systems outperform OODBMS. However, as time goes by the performance gap should diminish.

+ There is a larger population of people experienced in the use of relational database technology.

In addition, more COTS products have been developed to interface with RDBMSs than with OODBMSs. OODBMS technology is expected to continue to mature, and may eventually have the same type of widespread acceptance and utilization as RDBMS technology.

7.0 CTIS ARCHITECTURE

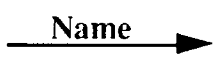
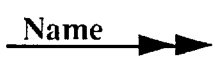
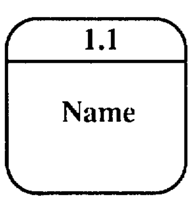
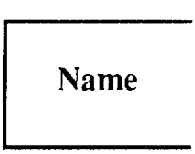
This section will present the logical and physical architectures for the Corridor-wide Traveler Information System developed Task 5 of the Project. In addition, major CTIS standards to be used in the detailed design and implementation phases will be described.

A structured, systems engineering methodology was followed for the development of this architecture. In performing this analysis, a functional decomposition technique, based on the Yourdon/DeMarco and Gane/Sarson methodologies, and a computer-aided software engineering (CASE) environment was utilized. Table 7-1 summarizes the notation used in the diagrams for this project.

7.1 HIGH-LEVEL LOGICAL ARCHITECTURE

A well designed CTIS architecture is one that fully complies with all agencies and end users needs, and which provides interfaces for existing and planned systems. To understand the various types of external interfaces with CTIS, a context diagram was developed. This section discusses the context for the I-95 Corridor-wide Traveler Information Services and provides an overview of the major CTIS subsystems. This logical architecture provides a foundation for deriving and instantiating a physical architecture. The physical architecture will be presented in section 7.2.

Table 7-1. Design Methodology Notation

Notation	Description
	Square boxes are external entities to the system. They are normally found on the context diagram. These are entities that transmit information to and receive information from the system.
	The arrow depicts a dataflow. Dataflows on the context diagram are normally composite dataflows. That is, they consist of sets of logically grouped data. In lower-level diagrams, composite dataflows are split into individual pieces. Dataflows and their composition are defined in a data dictionary.
	Same as above, except this dataflow depicts a continuous or synchronous flow of data between an external entity and the system. To adequately address communication requirements, it is important that the context diagram differentiate between synchronous and asynchronous interfaces. For composite data flows, if one or more element of the composite flow is synchronous, the whole flow has been tagged as synchronous.
	Square or rectangular boxes with numbers represent a process or functionality. In the context of this report the highest level is a subsystem, the intermediate level are components, and the lowest level elements. These boxes are functional areas of the system, they are not necessarily software processes. The number contained with the box maintains the tracking of parent and child relationships among the processes.
	Rectangular boxes without right hand borders indicate data stores for the system. These data stores may include databases, flat files, and computer memory.

7.1.1 Logical TIS Context

Figure 7-1 presents the context diagram of the I-95 Corridor Traveler Information Services. It shows the CTIS interfaces with external entities. Each external entity acts as a source and/or sink of the CTIS information. The CTIS receives information from the information sources for further processing and dissemination to the information sinks. The information sinks are mainly the CTIS users; but also include other entities with which CTIS shares data. A brief description of TIS context is provided below. The description contains discussions on each external entity and the related data elements. Explanation is also provided on some critical data elements.

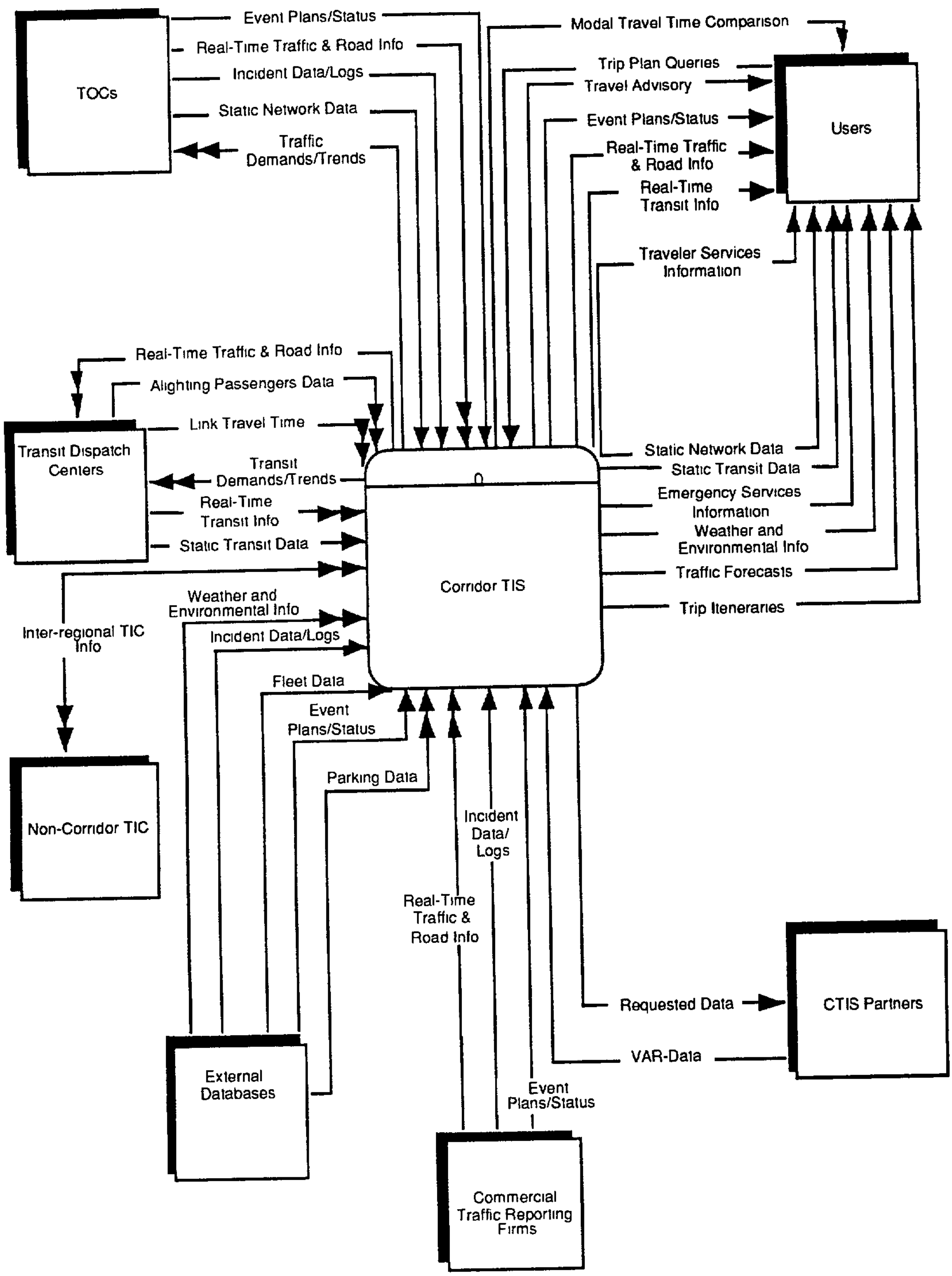


Figure 7-1. Context Diagram of the Corridor-wide Traveler Information Servi

7.1.1.1 Traffic Operation Centers (TOCs)

A primary source of CTIS data will be from traffic operations centers located throughout the I-95 Corridor. These centers will all exchange data with the CTIS over the Information Exchange Network (IEN).

The local and regional systems will gather local and regional information respectively, such as: real-time traffic and road information (e.g., post processed, validated link data), incident data and logs, event plans and status, and static network data. This mostly real-time information will be provided to CTIS, which will, in turn, supply the local and regional systems with traffic demand and trends information. It should be pointed out that each TOC may also be a user of the CTIS (reference the upper right corner of the context diagram).

7.1.1.2 Transit Dispatch Centers

Public and private transit dispatch centers will be the primary provider of transit related information to CTIS. Transit dispatch centers will gather data and information for bus, rail, air, subway, and ferry. Typical information available at a transit dispatch center would include real-time transit information, static transit data, and traffic demands and trends. CTIS will then supply the transit dispatch centers with updates to the projected demands and trends, based on actual public user information and the real-time transit information. Therefore, CTIS and the transit dispatch centers will work in accord to achieve maximum efficiency when exchanging transit related information. When applicable, information exchanged between these two systems will use the IEN.

7.1.1.4 Commercial Traffic Reporting Firms:

Commercial traffic reporting firms will be another source of relevant information for CTIS. Metro Traffic, Shadow Traffic, Traffic Net, SmarTraveler, and Traffax are all examples of the increasing presence of commercial traffic reporting firms in the Corridor. These external entities play an important role in both gathering data and disseminating information to the travelers through various broadcast media. Usually, Commercial Traffic Reporting Firms have their own surveillance assets, including air-borne surveillance. Although the actual operations of the firms vary substantially, the information required by CTIS is consistent; real-time traffic information, incident data and logs, and event plans and status. Interfaces with these commercial traffic reporting firms could potentially use the IEN.

Commercial Traffic Reporting Firms also receive relevant information from the CTIS. However, functionally these act as Users and hence are covered under the Users entity.

7.1.1.5 External Databases:

There are several types of databases that will maintain information relevant to CTIS. Typical information expected to be available from external databases includes weather and environmental information, parking data, fleet probe data, and geographic data.

7.1 .1.6 Non-Corridor Traveler Information Centers

Non-Corridor traffic information centers (TICs) do not lie within the geographic boundaries of the I-95 Corridor. For example, if a trip begins within the Corridor and ends outside, the traveler would be interested about the information at the destination. Hence, the CTIS will exchange (both receive and send) with the Non- Corridor TICs Inter-regional TIC Information. This may include includes traffic, weather and environmental, and construction information. The IEN will not be the mechanism for exchanging data with non-Corridor systems.

7.1 .1.7 CTIS Partners

Private-sector disseminators will exchange data with the CTIS on an as-needed basis or a synchronous basis. In general, the private-sector disseminators may have their own subscribers, and may wish to augment their own information with information available from the CTIS. The CTIS will have provisions to accept information requests from and send access grants and requested data to the private disseminators. In addition, the CTIS may receive value-added data from the private disseminators. For example, the CTIS may provide the link travel time information to the CTIS Partner entities which will further process the data to calculate the shortest path matrix for area-wide O-D pairs. This data then can be sent to the CTIS as Value Added Reseller (VAR) Data and used for subsequent route guidance requests.

Private sector disseminators encompass a wide range of information disseminators. Typical examples are information service providers, communication service providers, value-added resellers, hardware and software providers, media (TV, radio, newspaper), commercial traffic firms, and employers. These private disseminators would each have unique information needs and therefore would request relevant data as needed from CTIS.

7.1.1.8 Users

The users are the primary data sink, and of course, are the customers of the CTIS. The CTIS receives requests from the users and sends them the necessary information based on the travelers' needs. It is important to understand that the interface to users will be provided for the most part by private sector ISPs.

, The information flow from the CTIS to the Users entity includes basically all or a combination of the data residing in the CTIS database. The data includes:

- Modal Travel Time Comparison.
- Travel Advisory.
- Event Plan/Status.
- Real-Time Traffic and Road Information.
- Real-Time Transit Information.
- Traveler Services Information.
- Static Network Data.

+ Static Transit Data.

+ Emergency Services Information.

+ Weather and Environmental Information.

+ Traffic Forecasts.

+ Trip Itineraries.

The request that the CTIS receives from the Users is Trip Plan Queries.

7.1.2 TIS Subsystems

The CTIS has a number of subsystems as shown in Figure 7-2. The subsystems are designed to be modular in nature. Therefore, the entire system does not need to be implemented at the same time, but different combination of the subsystems can be implemented depending on the desired functionalities. Also, the entire system will not be located in the TIC, and individual subsystems and combinations thereof, can reside in segments in both TIC and at the user's end, such as in-vehicle navigation device.

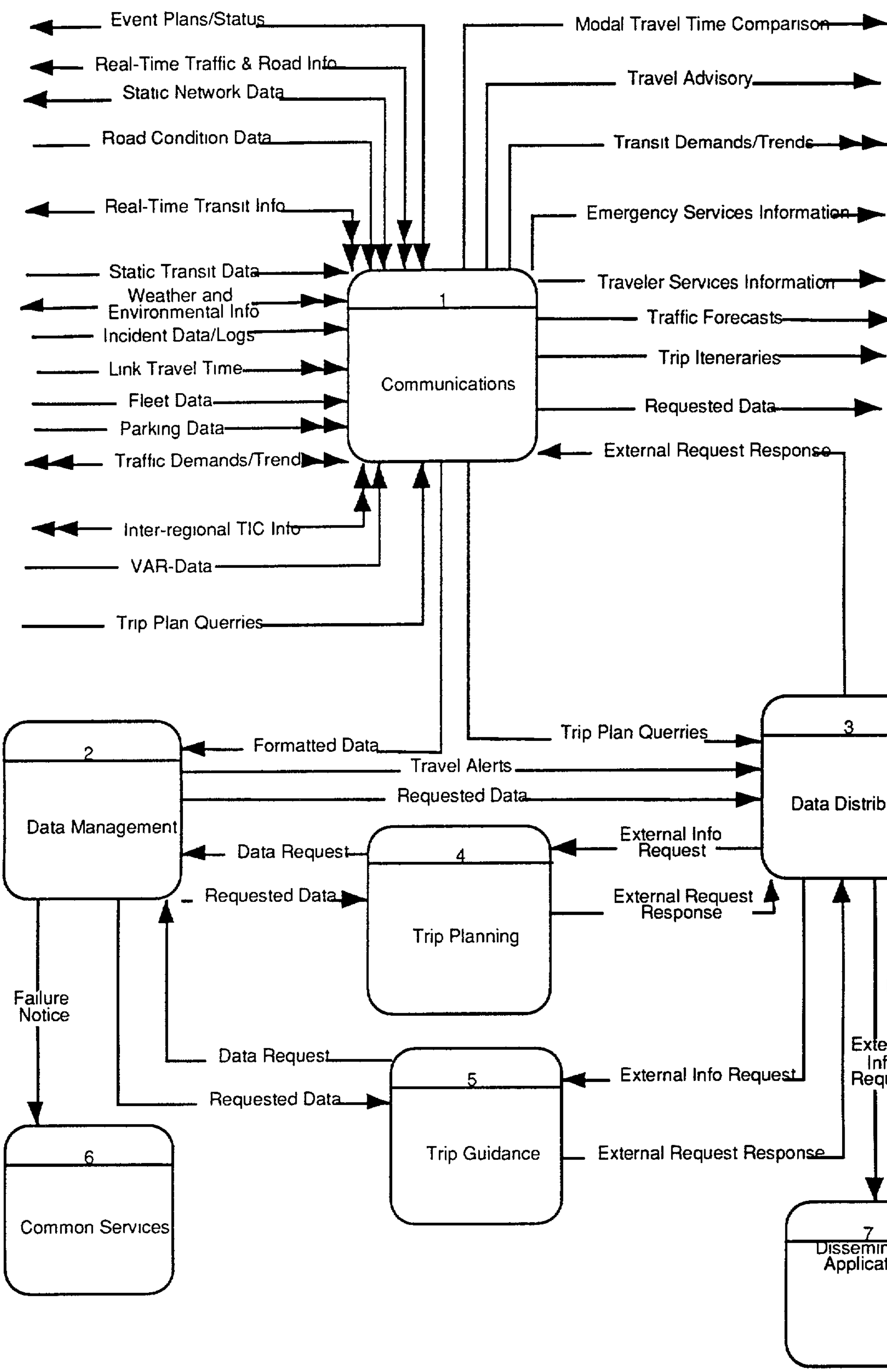


Figure 7-2. Level 1 Decomposition of CTIS

The subsystems are as follows:

- Communication. This subsystem provides the capability for receiving and sending data between the CTIS and the external entities.

- Data Manaaement. This is the core of the CTIS. This subsystem is responsible for validation, storage and retrieval of all CTIS data as necessary.

- Data Distribution. This subsystem is responsible for handling all external requests and information dissemination. It receives the individual external requests (both scheduled and ad hoc) for information, and routes to the appropriate subsystem applications. Once the information is processed, this subsystem sends it to the appropriate external entity. Since, this subsystem acts as the channel for incoming users' requests and outgoing information, it will also monitor the user activities (type of requested information and system time) and determine the relevant fees.

- Trip Planning. This subsystem provides users with the capability to plan a trip using a single or multiple modes of transportation. The plan will be based on the user selected criteria. It also includes the ability to look up traveler services information of interest.

- Trip Guidance. It provides explicit directions to the users on how to go to their destinations while they are in the vehicle. This includes vehicle maneuvering instructions.

- Common Services. These is a combination of subsystems that support other applications and the overall system. These common services include:

  - Graphic User Interface (GUI).
  - Software/Hardware Monitoring.
  - Security.
  - Configuration Manager.
  - System Management.

- Inter-Process Communication.

+ Dissemination Applications. This subsystem provides users with reports of traffic and transit status that affects their trips.

Detailed descriptions of the individual subsystems are provided in Sections 7.3 through 6.7. Further decomposition of individual subsystems are also presented.

7.1.3 Modularitv of the TIS Subsystems

The modular design of the TIS subsystems allows a mix and match of the subsystems to provide the desirable architecture. For example, Figure 7-3 illustrates an architecture that shows grouping of the subsystems for the TIC, hand-held devices, and in-vehicle navigation. The intent of this figure is not to recommend an architecture, but to illustrate the modularity with which various combinations of the subsystems can be implemented to achieve the desired functionality.

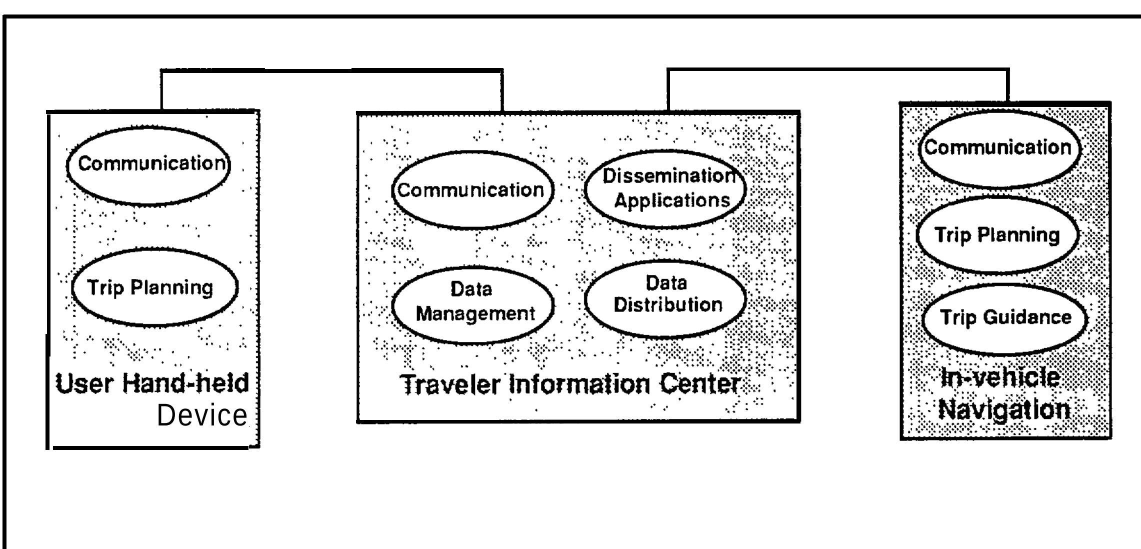


Figure 7-3. An Example of Flexible Grouping of TIS Subsystems

7.2 HIGH-LEVEL PHYSICAL ARCHITECTURE

In this section we will present a physical architecture, which represents one of many candidate instantiations of the logical architecture presented in section 7.2.2. The architecture was developed to map to the CTIS vision presented in Chapter 4. This section, therefore, will be discussed and illustrated in an incremental fashion, providing a clear mapping between the CTIS architecture elements and phases in the CTIS deployment vision.

7.2.1 Theme: Travelsheds. Not Jurisdictions

Corridor traveler information services are best organized according to how the traveler sees his or her world, rather than how the operating agencies see it. Consequently, Corridor traveler information services must rise above jurisdictional boundaries. The end user does not know *and* does not care who owns a roadway or in which city, county, or state he or she is.

Instead, he or she thinks of himself or herself in a "travelshed'. Just as a watershed marks where water flows in the same direction, a travelshed marks where (most) travel is concentrated. This includes not just travel in the same direction at a given time of day, that is, commuters inbound in the morning and outbound in the evening, but also business travelers arriving or departing to another "travelshed", and inter- and intra-travelshed commercial traffic.

The focus of Corridor traveler information services is best organized around the Corridor's five significant travelsheds:

- Boston (including Hartford, Providence, and northern New England).
- New York (including southern Connecticut, northern New Jersey, and northeastern Pennsylvania).
- Philadelphia (including Camden, Chester, Wilmington, and central and southern New Jersey).

- Baltimore-Washington (including northern Virginia).
- Richmond-Norfolk (including Hampton Roads).

These travelsheds correspond to the three consolidated metropolitan statistical areas identified by the U.S. Bureau of the Census in the Corridor, plus aggregations of the Baltimore and Washington, and Richmond and Norfolk standard metropolitan statistical areas. In order to avoid the development of a centralized architecture (requiring an enormous communication infrastructure), the candidate architecture presented in this section will assumes Regional Traveler Information Centers (RTICs) that map to these travelsheds.

7.2.2 Regional Traveler Information Centers

Since the I-95 Corridor consists of several regions, and hosts over 20% of the total U.S. population, a distributed architecture, illustrated in Figure 7-4, was developed. A distributed architecture is envisioned not just for technical reasons (greater system redundancy, and a manageable set of communication interfaces), but also for geographical reasons. The spatial distribution of the population in the Corridor lends itself to the development of a distributed architecture. As illustrated, each of the regions (also identified as travelsheds) will house a regional traveler information center (RTIC), which will act as a clearinghouse for transportation information within its service area. To support Corridor-wide traveler information, each RTIC must be able to communicate with any other RTIC. Inter-RTIC compatibility is required to support the Coalition's goal of providing traveler information at any point in the Corridor about any other point in the Corridor. To facilitate this capability, the development of each RTIC must adhere to format and protocol standards that define information to be shared between RTICs. In addition, to support maintainability and an open architecture providing easy access to data by the private sector it is recommended that each RTIC comply with various established and de facto standards as identified in Table 7-2.

To maximize the use of existing resources, it is envisioned that each RTIC will come on-line over time and be co-located with an existing TOC or private-sector ISP. For instance, SmartRoute Systems may serve as an RTIC in the New England area: TRANSCOM as the RTIC in the New York, New Jersey, Connecticut area, and the Maryland State Highway State-wide Operations Center (SOC) as the RTIC in the Baltimore, Washington, Northern Virginia area. Regardless of whether a private-sector ISP or a public agency hosts the function of the RTIC, it is anticipated that

Table 7-2 Architecture Complies with Existing and De facto Standards

Requirement	***Recommended Standard-Approach***
Unix/NT	POSIX Compliant Unix & TCP/IP
C/C++	ANSI C/C++
X-Windows	OSF Motif
Object-Oriented	Rumbaugh's Object-Modeling Technique (OMT)
Relational Database	ANSI SQL, RDBMS
User-Friendliness	FHWA Human Factors Compliance Demonstrated through Simulation & Prototyping
GIS	SL-GMS, ArcView II or GDS
Expert Systems	Rule-Based and Case-Base Solutions
Scaleability	Client-Server/RISC Platforms

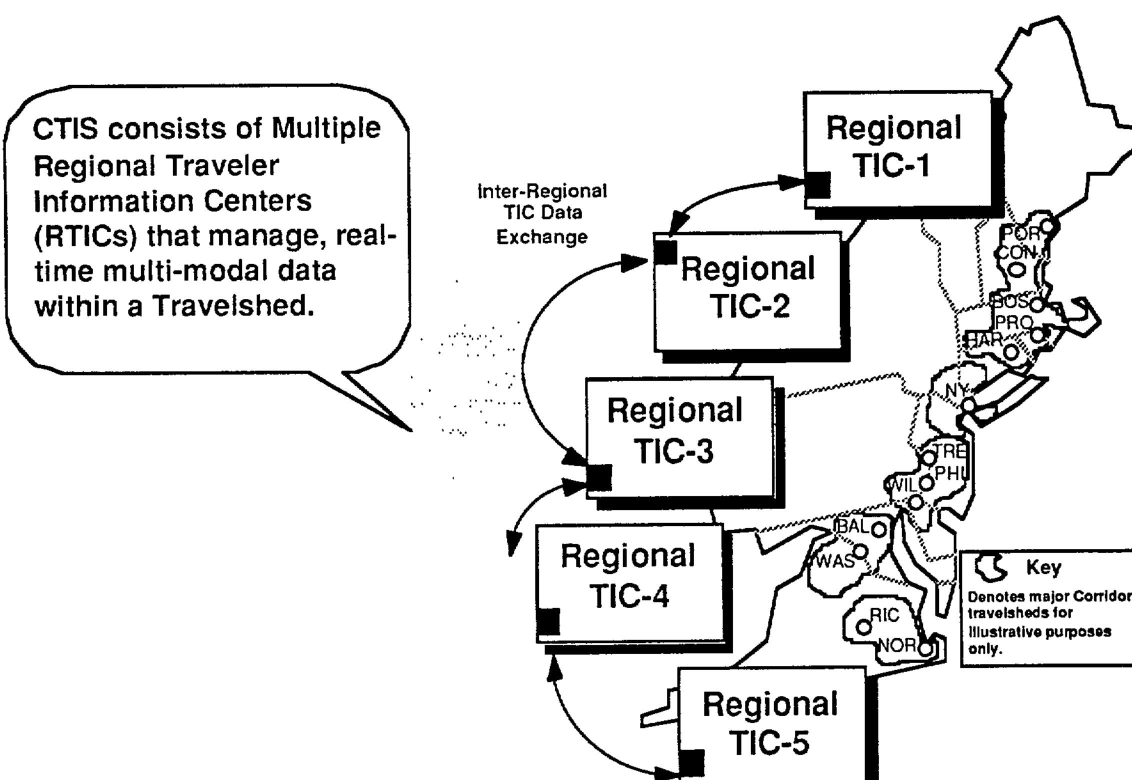


Figure 7-4. High-Level CTIS Block Diagram Illustrating Candidate CTIS Regions

each RTIC will require a public/private partnership for the design, implementation and operations and receive initial public funding to help jump-start and "prime" the system. Over time, however, full privatization may occur as CTIS and traveler information markets mature.

The primary goal of each RTIC is to compile, integrate, format, and manage data to be distributed to end-users, ISPs and other RTICs; thus, the regional centers are the engines for the traveler information marketplace. To meet this goal, four major functions are required:

+ Data gathering.

+ Data fusion and processing.

+ Data delivery.

+ End-user device data processing.

The first three functions are the responsibility of the RTIC and in most cases the last function, end-user device data processing, is the responsibility of the ISP. The relationship between these functions and the logical subsystems is identified in Table 7-3. Each of these four functions will be further explained below.

Table 7-3. Mapping Between Logical Subsystems and RTIC Functions

RTIC Function	*Logical Subsystem*
Data Gathering	Communications, Data Management
Data Fusion and Processing	Data Management, Trip Planning, Trip Guidance, Dissemination Applications
Data Delivery	Data Distribution, Communications
End-User Device Processing	ISP/Product Vendor function

7.2.2.1 Data Gathering

Providing seamless access to regional traveler information begins with the task of data gathering. To appear seamless to the user, traveler information must be collected locally and integrated regionally, since travelers do not recognize imaginary boundaries such as state, county or city borders. End-users seldomly require information only for a given city or county jurisdiction. This is partly due to the pervasiveness of suburb-to-suburb travel in the transportation network, and the fact that employees no longer reside close to their place of employment. The implication of appearing seamless is that traffic/transit surveillance and condition information must be collected and integrated from multiple public and private agencies. Figure 7-5 identifies the various CTIS sources of information and illustrates the relationship between RTICs, Traffic Operation Centers (TOCs) and IEN interfaces. The principal data to be collected will include traffic and transit data obtained from Traffic Operation Centers (TOCs) and Transit Dispatch Centers (TDCs), respectively. It is envisioned that the interfaces to the TOCs and TDCs will occur through an Information Exchange Network (IEN) interface.

Since most traffic surveillance data is collected locally, regional data gathering activities require many system interfaces to information sources. RTIC system interfaces supporting center-to-center (i.e., TOC to RTIC, Transit Dispatch to RTIC, etc.) information exchange of voice and digital data are required. Unfortunately, not many existing jurisdictions have systems in place that electronically share/exchange data. Because of this fact, the Coalition is sponsoring Project #1, the IEN. The IEN is tasked with resolving this problem through the deployment of a uniform network backbone throughout the I-95 Corridor. The IEN backbone will host over 67 IEN nodes strategically deployed at various Coalition member agencies. The IEN nodes will obtain local traffic data from each TOC. Acquired data will be in a unique format native to the host system. Data will be acquired and translated into a canonical IEN format that will be made available to other IEN nodes and RTIC data servers. Initially, the TOC to IEN interface will be manual. In the future, automated interfaces will be provided to reduce human intervention and duplication of effort.

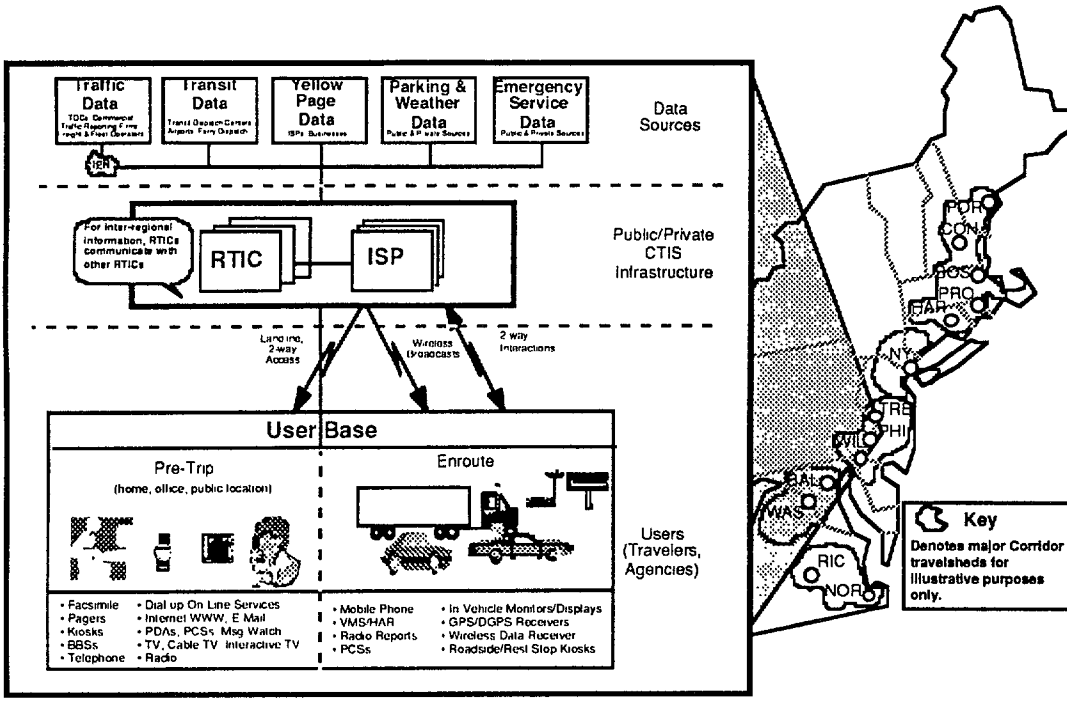


Figure 7-5. CTIS Block Diagram: Illustrating Coupling Between RTICs and Regions and Private-Sector Involvement Through ISPs

7.2.2.2 Data Fusion and Processing

Once information is acquired, and prior to it being delivered to end-users, data must be fused, formatted, and further processed. Fusion includes consolidating and correlating data about the same point or area in the transportation network, from multiple sources. For example, consolidating incident reports from commercial traffic reporting firms (acquired via aerial surveillance or motorist call-in) and public agencies (acquired via instrumented roadways and detection algorithms) is typically required. It is important to note that not all data coming into the system is fused. For example, transit schedules are simply acquired and stored. Once data is acquired it must be validated and put together into formats to be used by other CTIS applications -- for example, trip planning. This may involve calculations combining one type of data with another, or aggregating the same kind of data together. In order to support route or modal travel time comparisons, for instance, data must typically be aggregated. For example, to determine travel times between cities (e.g., Baltimore-Washington) low-level link data, typically obtained at 0.5 mile intervals, must be combined together to form a route travel time estimate. Finally, acquired, fused and formatted data must be spatially attached using geo-referencing to a base map or spatial model.

A key element inside each RTIC is a data management subsystem that will use relational database servers to manage traffic and transit data. Each of these regional data servers will collect and maintain data within its region in order to satisfy the needs of intraurban, interurban, and interregional travelers. In addition to acquiring data, the regional data servers will also disseminate information to other regional data servers and to the other nodes on the IEN. The kind of data exchanged between regions and the frequency of update is dependent on the proximity of regions, performance, available bandwidth, user needs and other factors. It may not be desirable or required to transmit synchronous link data between RTICs, until a well-defined need is identified. This would not precluded the ability for a given RTIC to on-demand, poll another RTIC for a link update. On the other hand, for system redundancy and possibly performance, it may be desirable to have all link data exchanged between adjacent RTICs.

7.2.2.3 Data Delivery

To disseminate traveler information effectively and to provide ubiquitous access to all types of users, public/private partnerships comprising Coalition member agencies and various private-sector sponsors are required. Commercial endeavors by ISPs, VARs, CSPs, and various other types of repackagers, distributors, and other providers of traveler information products and services are envisioned. These private-sector entities are expected to add information, package traveler information with other types of information, and disseminate information directly to end-users to enhance the effectiveness of the regional traveler information center. As illustrated in Figure 7-6, actionable, real-time traffic and travel information will be collected and disseminated (by both the public and private sectors) on all modes, including private vehicles, and public and commercial transportation.

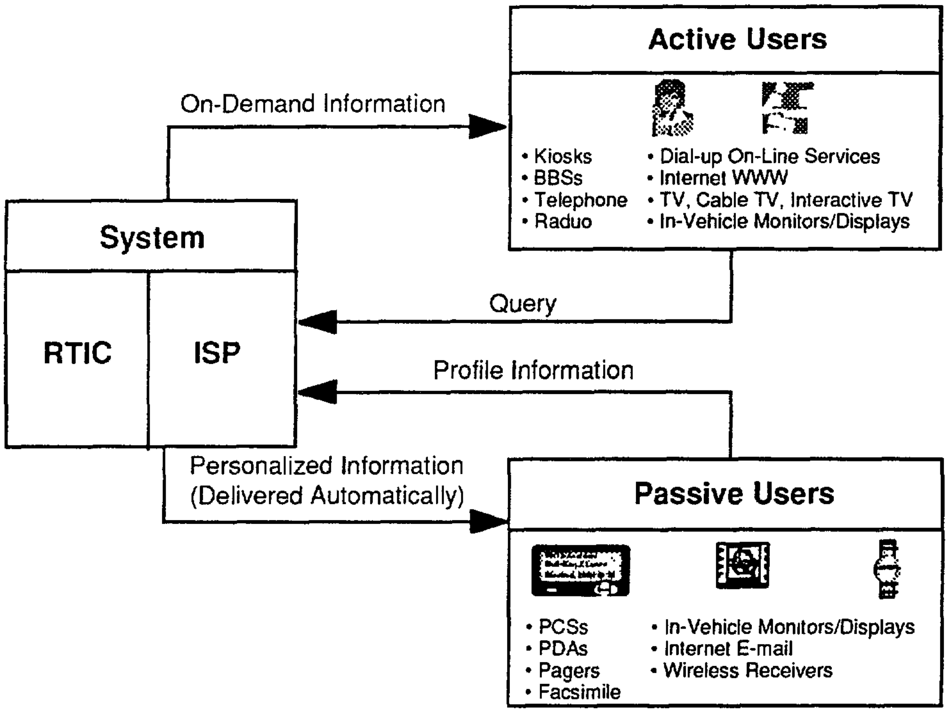


Figure 7-6. RTIC Architecture Supports Active and Passive Users

Dissemination of traveler information will likely occur in phases (as previously discussed), progressively adding more services and incorporating sophisticated technology over time. Figure 7-7 illustrates a concept of providing various levels of support for traveler information. In the short-term baseline phase (years 0-2), TIS will disseminate primarily via proven communication media: Commercial Radio Stations, VMS/HAR, Faxes, Pagers and Telephone. During the mid-term phase (years 2-5), more sophisticated private-sector information dissemination proliferates. Information will contain more multimedia components, and from the user's point of view will be more interactive and personalized. Dissemination technologies/devices will include regular, cable and interactive TV; dial-up on-line services; public kiosks; Internet accessed services; and various types of hand-held devices including, two-way pagers, personal digital assistants (PDAs), and personal communication systems (PCSs). In the final phase (years 5-10), heavy emphasis will be placed on widespread deployment of in-vehicle navigational devices displaying real-time, location-specific, multi-modal navigational information. In addition, the use of intelligent agent processing will begin to be used. This technology will be employed to automate the information retrieval and delivery processes (i.e., from the user's point of view), and to increase the amount of personalized information, thereby facilitating more passive users who receive information only on an as needed basis. As shown, various levels of costs will be incurred by the user varying from free for broadcast information, to premium costs for personalized, automatically delivered information.

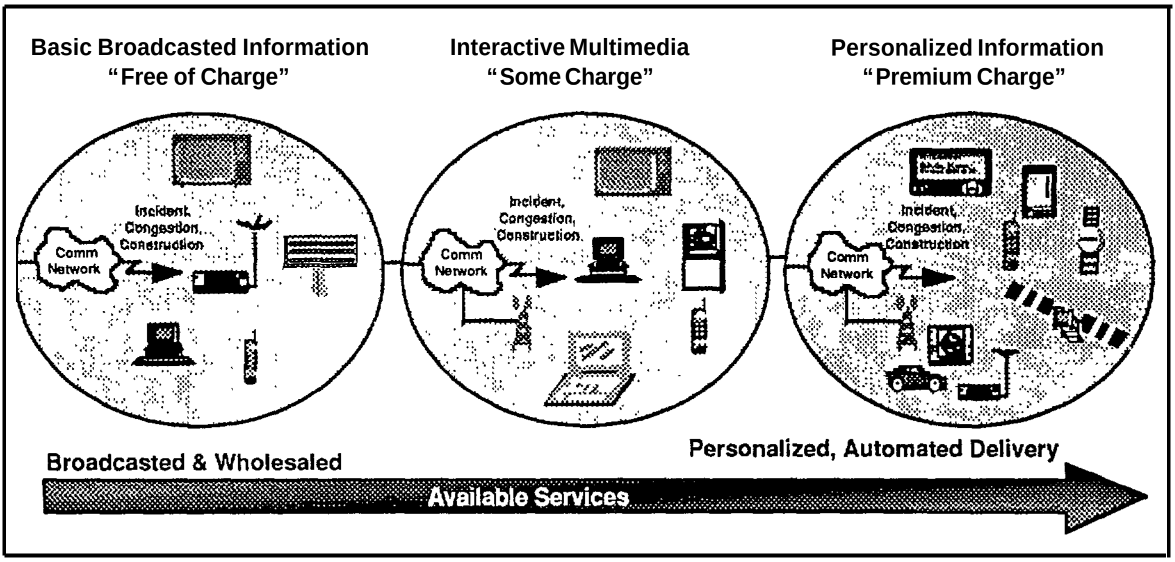


Figure 7-7. RTIC Architecture Supports Multiple Levels of Service

For a comprehensive illustration, Figure 7-8 identifies the various information sources and sinks of a given RTIC.

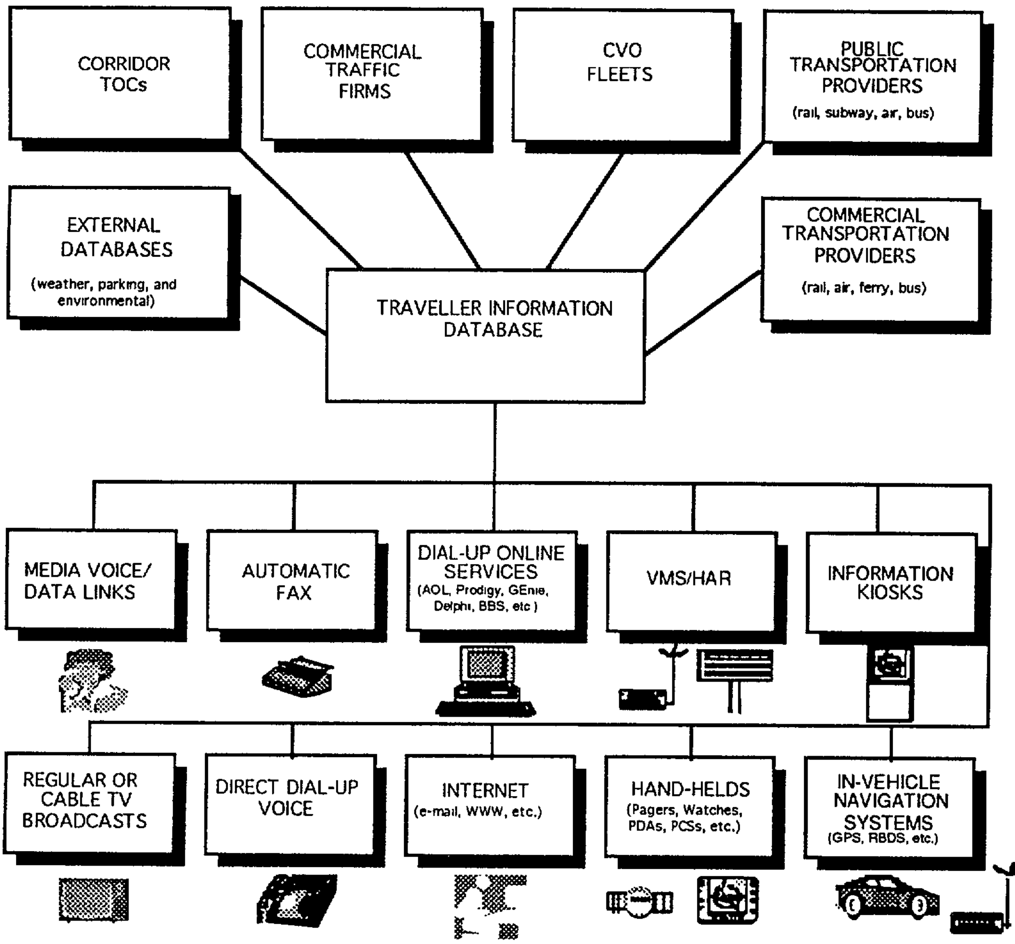


Figure 7-8. CTIS Architecture Identifying Data Sources and Sinks

7.2.2.4 End-User Device Data Processing

While most end-user device data processing is likely to be a private-sector function, several end-user devices are likely to provided by public agencies. These include, VMS/HAR, kiosks, and the telephone.

Regardless of the device and the provider, all end-user device data processing begins with acquiring traveler information. Then, depending on the device and vendor, device specific data processing occurs. These functions include, formatting, user-specific filtering, data presentation and display. In addition, for devices supporting two-way communications (Computers, PDAs, next-generation pagers, kiosks, etc.), support for the construction, retrieval, and display of ad-hoc and fixed queries is required.

7.3 RTIC COMMUNICATION ARCHITECTURE

Each RTIC will provide a communication architecture capable of accommodating interfaces to other RTICs, agencies, users and the private sector. Each RTIC will support interfaces for local networks, Wide Area Networks, and switch elements which connect to public phone lines. Figure 7-9 shows how a typical RTIC will interact with the various communication elements. The RTIC exchanges data with TOCs/TMCs (even if the RTIC is co-located within the TOC/TMC building) via a local gateway. This network interface allows for the exchange of data between the RTIC data processing equipment and the TOC/TMC. The TOC/TMC network(s) are isolated from the other CTIS elements since the data exchange is controlled by the local gateway. This interface can be a network, such as Ethernet, using compatible communications equipment connected to a subnetwork. This subnetwork allows for the distribution of RTIC network information among the various data processing equipment within the center.

Inter-regional data networks are configured using the same gateway approach to allow the exchange of data to be controlled by the RTIC. Again these networks can be Wide Area Networks (WAN) using a compatible protocol such as DS1 . The equipment used here may include the following:

+ Network modem(s) - Used to connect to the public switch or the landline network.

+ Bridge(s) - Used to modify the WAN format to a local network protocol.

The RTIC's data processing equipment will have the capability of monitoring the WAN for operational reliability.

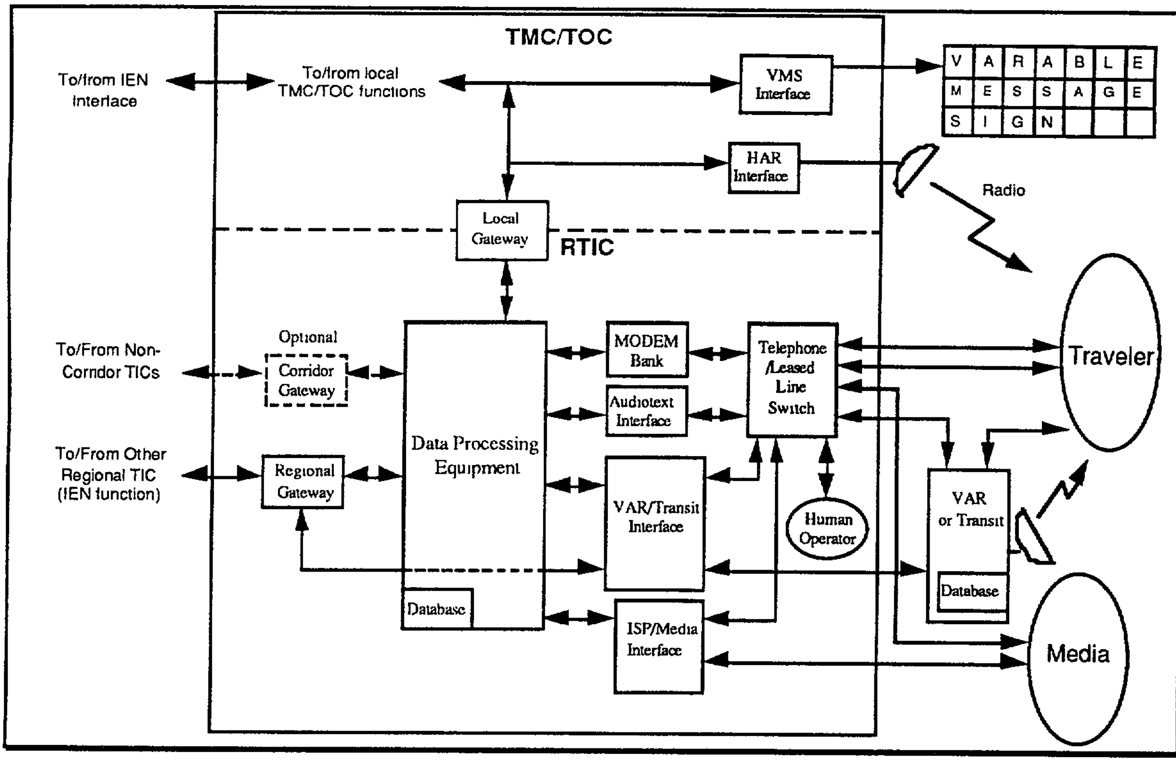


Figure 7-9. Typical RTIC Communication Architecture

At the local level an ISP or media entity enters through a dedicated interface or through a dial-up modem. This interface allows the service provider controlled access to the CTIS's data and satisfies the specialized data requirement of the ISP/partner. The typical equipment used here is analog and digital video/voice equipment, specialized modems, and network switch components. In addition, the traveler has access to the CTIS via the RTICs leased lines. Queries enter the CTIS via commercial modem, or audiotext equipment connected to the RTIC's data processing equipment.

To adequately assess the bandwidth requirements for the communication network between the RTIC and the TOCs, the following are relevant facts and assumptions that have been made in our analysis:

- The RTIC to TOC interface will handle two types of data: synchronous and asynchronous data. Synchronous data includes link-based data from instrumented

Corridor freeway and arterial roads, that is transmitted on a regular basis. Asynchronous data includes, incident and construction reports and static information, such as road geometries, turning restrictions, etc. Incorporating network overhead for error checking, framing, and packetizing, each link will require 610 bytes of information. Incorporating network overhead for error checking, framing, and packetizing, each incident record will require 500 bytes of information.

+ Project #3, Surveillance Requirements/Technology **(SRT)** has identified that the Corridor has approximately 5600 miles of roadways (including freeways and arterials). Of the 5600 miles, approximately 1600 miles (or 30%) of the roads have existing or planned surveillance coverage. We assume that over the next 10 years, 3200 miles of roads would be instrumented with surveillance equipment. Dividing these 3200 miles by 5 RTICs yields an average of 640 miles of roads under surveillance by each RTIC.

+ We further assume that the average length of a roadway link is a total of 640 one-way links per RTIC. Thus, the highest synchronous communications scenario would be one where traffic condition updates from all 640 links are required during one-minute intervals. In reality, it is likely that only links exceeding , say, a 25% reduction in speed will be transmitted, representing a lower communication demand.

+ A recent survey conducted by Project #1 , has revealed that there are approximately 35 existing and planned centers, including TOCs, Police barracks, and Emergency Response Centers) throughout the Corridor. Of the 35 centers, it is estimated that 22 centers that operate traffic control devices will place synchronous communications demand on the network.

In summary, from a communication point of view, each RTIC will be required to interface to 7 operations centers on average, only 5 of which are generating synchronous data. Based on these conditions the following bandwidth is required for each RTIC: ((640 links/RTIC * 610 bytes/link) * 8 bits/byte) / 60 seconds/minute) = 52K bps.

7.4 CTIS DEPLOYMENT VISION

The I-95 Corridor Traveler Information Service will evolve over a period of years, going through three identifiable stages, each with its level of technology, public and private partnership funding, and level of TIS demand, and inter-jurisdictional collaboration.

7.2.4.1 Phase I Deployment (Years 0 - 2)

Phase I-Baseline Information Dissemination (Years 0 - 2) - this phase is focused on rapidly deployable, baseline information dissemination to the broadest possible public, at little or no charge. This includes, the use of dial-in bulletin boards and Internet web pages, faxes, and pagers.

As an illustration, Figures 7-10 and 7-11, identify CTIS architecture elements that are readily deployable.

Figure 7-10 identifies a telephone traveler information system that uses audiotext technology. This architecture element could be provided by either the public or private sector and is one of the direct interfaces to the public. The system could be implemented by using an 800 number or, if possible, by providing the same number in each area code in the Corridor. This architecture element provides real-time traffic and transit reports to anyone with a touch-tone telephone. Access to the information would be menu-driven and delivered in the form of a human recorded, synthesized or digitized voice. A top-level menu structure, broken down by region, is depicted in Figure 7-I 0.

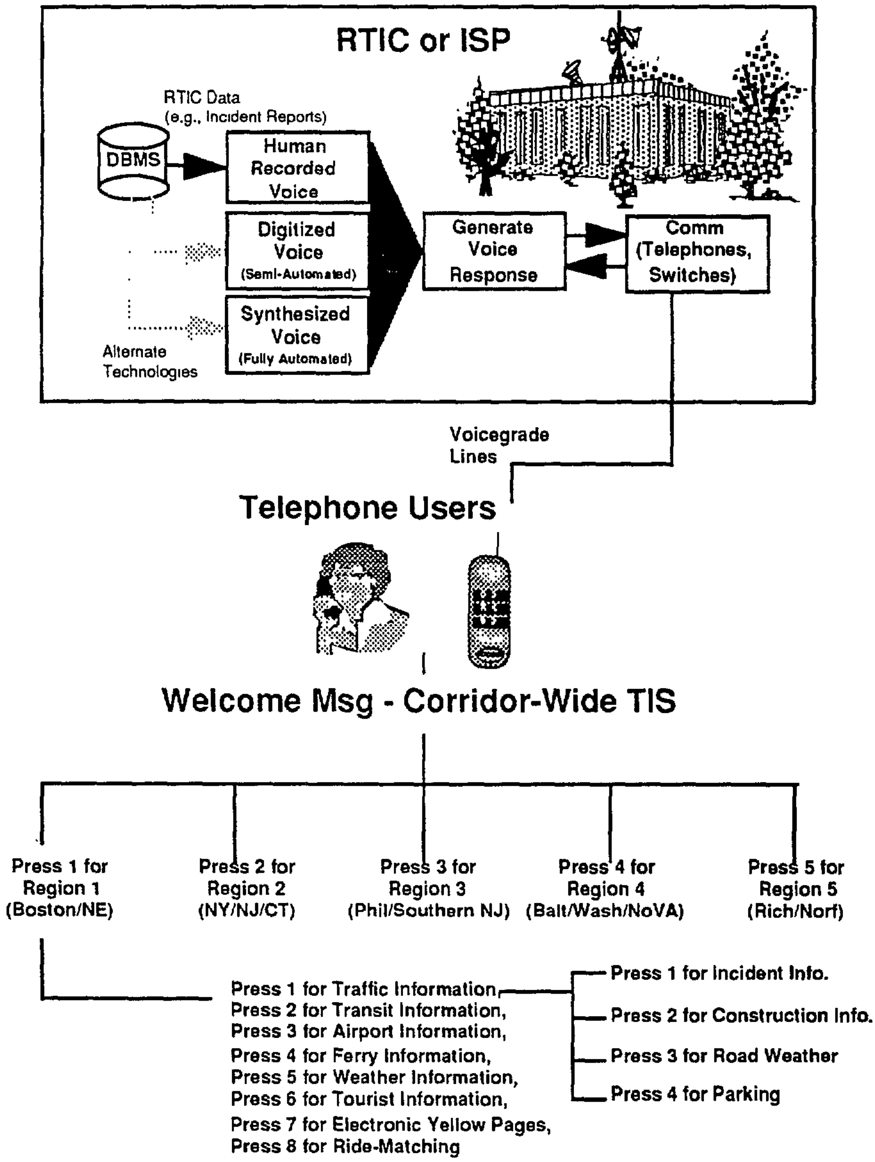


Figure 7-10. Candidate Architecture for a CTIS Audiotext System

Figure 7-11 identifies a candidate architecture for a World Wide Web (WWW) home page or dial-in Bulletin Board Service. The use of the Internet to disseminate traveler information as well as a myriad of other types of information (entertainment, technical, etc.) is becoming much more pervasive. Internet users are now estimated to be approach the 40 million mark. Delivery of traveler information through the World Wide Web (WWW) is an emerging technology. Probably the most advanced of such technology in this country is a service providing real-time traffic conditions in Southern California (San Diego and Los Angeles). The use of a specialized Bulletin Board Service provided by the CTIS may offer another alternative to disseminate information electronically. A BBS could be developed during Phase I to provide information to ISPs only. The general public would not interface directly to the BBS, as this capability would best be incorporated into existing on-line service providers (e.g., America Online, Prodigy).

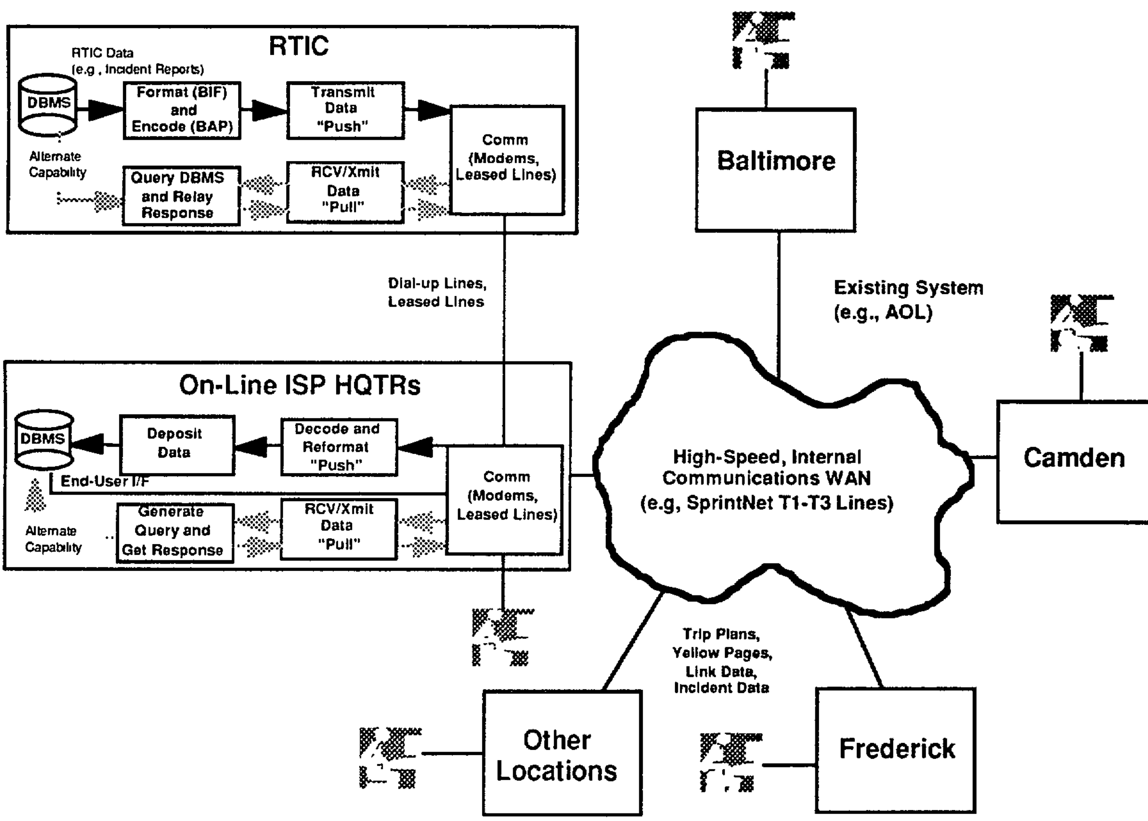


Figure 7-11. Candidate Architecture for a CTIS WWW/BBS Service

7.2.4.2 Phase II Deployment (Years 2 - 5)

Phase II—Multimedia, Interactive Information Dissemination (Years 2- 5) - this phase is significantly different to the end-user. Induced in part by the widespread dissemination and utilization of baseline information in Phase I, more sophisticated private-sector information dissemination media proliferates. As an illustration, Figures 7-11 - 7-13, identify CTIS architecture elements that are anticipated for deployment during Phase II.

Figure 7-l 1 identifies a candidate architecture for interfacing an RTIC with an existing on-line service provider such as, America Online or Prodigy. As depicted, two alternatives are provided in the architecture: 1) the on-line ISP may receive synchronous data through a “push” strategy or may alternatively request data on an as needed, on demand basis. Information obtained from the RTIC database is then incorporated into the Online ISP database and then made available to their users via existing client communications and display software. To transmit data from the RTIC to the Online ISP will require the use of formatting and encoding standards. The recommended formatting standard is version 3.1 of the International Traveler Information Interchange (ITIS) Bearer Information Format (BIF) and Bearer Application Protocol (for encoding). These standards are currently being finalized by Enterprise and field tested by many U.S. Field Operational Tests. It is anticipated that most of the data currently earmarked for dissemination to ISPs (and wireless receivers) is supported by BIF/BAP. Lessons learned from other FOTs have revealed, however, that additional messages and codes maybe required to support the Corridor’s RTIC traveler message subset. Finally, the specific BAP (e.g., FM subcarrier) to be used for the wireless communications is deferred until the implementation process when additional design considerations (e.g., coverage areas, functionality, duplicity, bandwidth) can be evaluated.

Figure 7-12 identifies a potential architecture for disseminating information to hand-held devices. This architecture element requires the use of a wireless communication infrastructure, typically owned and operated by private-sector communication companies. To transmit data from the RTIC to the ISP and from the ISP to the user will require the use of formatting and encoding standards. The ITIS BIF and BAP standards are also suggested for use here.

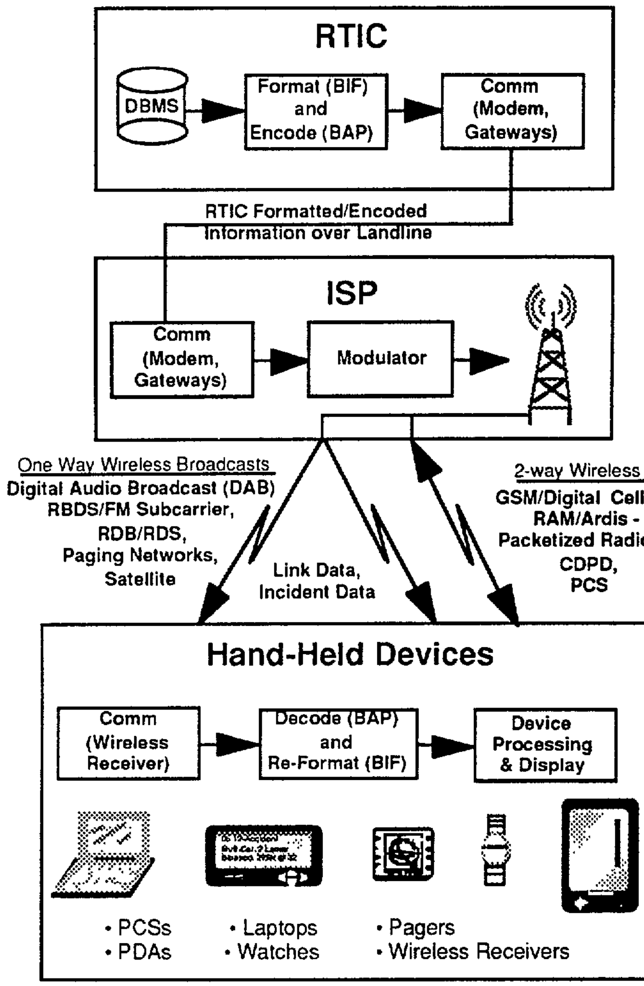


Figure 7-12. Candidate Architecture for Disseminating Information to Hand-Held Devices

Figure 7-13 identifies a potential architecture for interfacing to an existing Kiosk ISP (e.g., Discover America). This architecture mirrors very closely that of the RTIC to Online ISP presented in Figure 7-11.

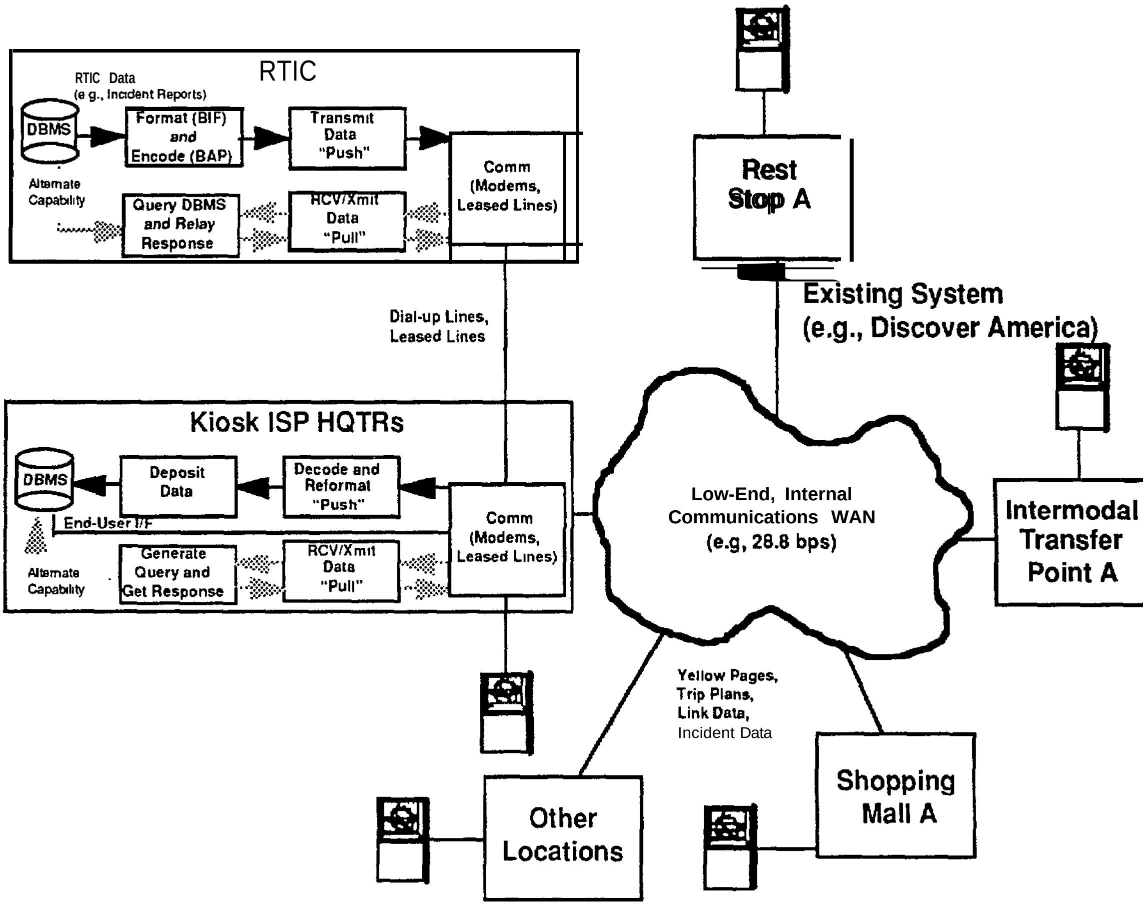


Figure 7- 13. Candidate Architecture for Providing an Interface to a Kiosk ISP

7.2.4.3 Phase III Dealovment (Years 5 - 10)

Phase III--Real-time, In-vehicle Information Dissemination/internally Contained (Years 5-10) - in Phase III, heavy emphasis in CTIS shifts to widespread deployment of in-vehicle navigational devices displaying real-time, multimodal navigational information.

As an illustration, Figure 7-14 identifies a candidate architecture for providing in-vehicle traveler information. The basic infrastructure for communicating information to an ISP is similar to that in the architecture elements shown in Figures 7-12 - 7-14. Note that the architecture provides support for various types of in-vehicle services, including yellow pages, route guidance, parking data, incident data an link data. In addition, mayday requests and probe-data may flow back to the ISP, where two way communication infrastructures exists. The RTIC to in-vehicle architecture supports varying levels of sophistication in terms of route guidance. No assumptions are made or requirements levied with respect to the positional accuracy of the vehicle (in the event of on-board GPS) or the degree of coupling between routing and control. This architecture does assume, however, than an ISP will handle the communication, processing, and display of information to in-vehicle devices, entirely provided by the private sector.

As illustrated in the Figure, two communication architectures will evolve or co-exist: 1) two-way, interactive and 2) one-way broadcast. The ultimate ISP will be responsible for selecting the most efficient carrier and technology.

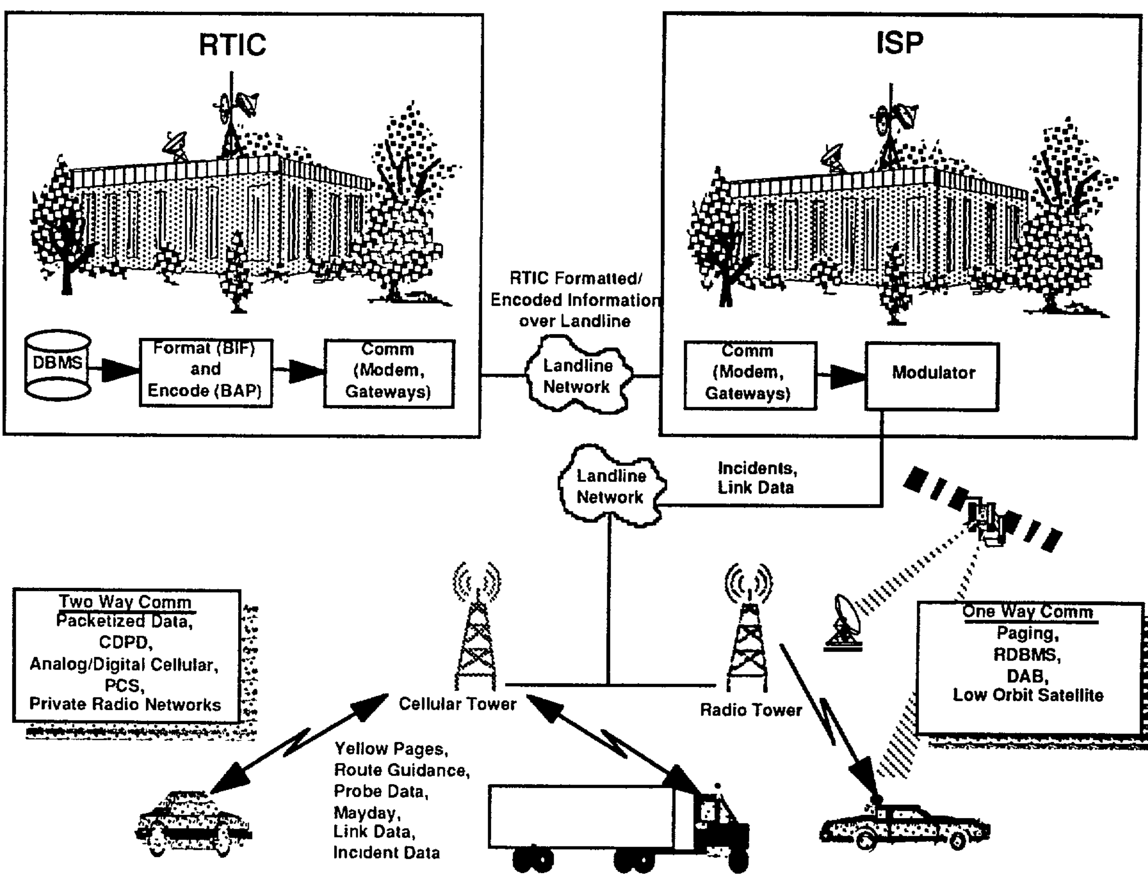


Figure 7-14. Candidate Architecture for Disseminating In-Vehicle

Table 7-4, summarizes the deployment schedule and the service provider of various TIS technologies. This table does not preclude the opportunity for services transitioning from public to private operation.

Table 7-4. Service/Deployment Phasing

	Deployment					Service Provider			
Service	Baseline	Year 2+	Year 5+	Year 10+	RTIC	ISP	Transit	Media	TMS/TOC
On-line Computer Service		X			X	X			
In-vehicle Device				X		X			
HAR	X								X
Public Kiosks			X			X	X		
VMS	X								X
Cable TV		X						X	
Network TV		X						X	
Telephone Menu	X				X	X			
Pagers		X				X			
Hand Held Devices			X			X			

7.5 STANDARDS

The Corridor-wide Traveler Information System will conform to relevant industry standards and conventions to ensure that the system is modular, interoperable, and extendible by third parties. In particular:

- its user interface will conform to Motif and Xlib;
- its main programming languages will be ANSI C and C++;

+ its operating systems will be POSIX-compliant Unix and Windows NT; and

+ its database will use ANSI Structured Query Language.

In addition, CTIS will use the International Traveler Information Interchange Standard (ITIS) for exchanging information between regional centers, between each regional centers and its "suppliers", and between each regional center and its "users" or 'customers".

All geographic data will use a common geocoding and mapbase.

7.5.1 International Traveler Information Interchange Standard

The ENTERPRISE program, a forum of several American states and a Canadian provinces for collaborative activities in intelligent transportation systems, is pursuing the development of the International Traveler Information Interchange Standard (ITIS) for advanced traveler information systems applications. ITIS is an open, non-proprietary, modular set of standards intended to serve the public interest by facilitating interconnection and interoperability of traffic and traveler information systems. ITIS has been developed in accordance with the 'Virtual architecture" concept. In this approach, the information system architecture is transparent to users and system operators alike. Rather than attempting to impose a single, fixed solution to this system architecture challenge, ITIS supports multiple compatible solutions, or flexible architectures, through the adaptation of common information language or subsystem interconnection and integration.

The ITIS approach offers machine-selectable language independent information dissemination, non-proprietary coding, consistent data interchange between traffic operations centers, and the ability to use a variety of communications media to meet specific needs. Potential ITIS communication bearers include AM and FM radio subcarriers, television subcarriers, radio paging, and cellular radio, and emerging approaches such as low-earth-orbit satellite or digital audio broadcasting. ITIS comprises a set of separate but related volumes, which together specify the proposed modular set of standards intended to serve the public interest by facilitating interconnection and inter-changeability of traffic and travel information systems. The Bearer-Independent Format (BIF) defines those parts of ITIS that are applicable to all communications media or bearers. Other volumes-the Bearer Applications Protocol (BAP) specifies means of applying the BIF to given bearers (i.e., rules to format messages for specific communications media).

ITIS BIF format specifies the contents of travel data records which can be exchanged between centers in language independent formats suitable for automated processing, sorting and selection. The travel information covers traffic event, route guidance, parking and transit. It defines the relevant data dictionary, the structure and content of data records and their presentation to the user.

7.5.2 Common Geo/Link Referencing System

For in-vehicle navigation and other advanced traveler information system applications, a basic prerequisite is a computerized road map, or to be more precise, a digital road network structured into links and nodes, together with other traffic and service-related attributes such as street names, street directions, turn restrictions, road classifications, business listings, plus a host of other items, to provide a geographically referenced system. This section discusses the standards, and data requirements for the digital map database in TIS applications.

7.5.2.1 Types of standards for Digital Map Databases

Standards for digital map databases must be available or developed to permit database vendors to consistently and accurately describe their products and to permit application developers to match available databases to their needs. There are four basic standards applicable to digital map database:

+ Truth-in-Labeling Standards.
+ Transfer or Interchange Standards.
+ Content or Minimum Performance Standards.
+ Standard Nationwide Database.

The first two standards, Truth-in-Labeling and Transfer or Interchange Standards, are the major North American initiatives in digital map database standards. The Truth-in-Labeling standards are developed by the Database Standards Committee under the ITS Division of the Society of Automotive Engineers. The initial scope of Truth-in-Labeling standards is digital maps for passenger vehicle applications. The U.S. Geological Survey (USGS) has developed a Spatial Data Transfer Standards for the purposes of establishing transfer or Interchange Standards. These two standards establish the framework and guidelines in the two most important areas for digital map database, and will be discussed in more details in this Section. The last two standards will be discussed very briefly for information only and are not considered suitable for the application of TIS.

Truth-in-Labeling Standards provide a consistent method for describing and comparing map database, and consist of definitions to identify relevant database items and relationships, as well as mechanisms for database producers to consistently specify the degree of quality (coverage, accuracy, currency, completeness, distribution of errors, etc.) of their databases.

The Truth-in-Labeling Standards are composed of three kinds of specifications related to the content and characteristics of a digital map database:

+ Definitions: define precise specifications of the entities to be included in database;
+ Metrics: provide scales or criteria for consistently measuring database quality;
+ Tests: score the entities against each of the corresponding metrics.

A Truth-in-Labeling standard allows a system developer to choose the database most appropriate for his particular application. However, a Truth-in-Labeling standard does not specify minimum requirements such as quality or content standards, which will surely be different from application to application: it merely provides a consistent and reliable mechanism for conveying information on database content, coverage and quality.

Transfer or Interchange Standards focus on the transfer of spatial data between databases by specifying common terms and formats for the data. Transfer standards provide a common format to and from which other database formats can be translated. A transfer standard does not prescribe the quality or accuracy of the data, although quality characteristics are often part of the information exchanged.

There are three prominent interchange Standards that have been developed. They include the American Spatial Data Transfer Standard (SDTS), European Geographic Data File (GDF) and Japan Digital Road Map Association (JDRMA). SDTS is now a Federal Information Processing Standard (FIPS).

SDTS is an open and general standard for the exchange of spatial data and was designed to serve a variety of applications, including cartography, geography, geology and Geographic Information Systems (GIS). SDTS is made up of three main pans: a logical superstructure, a list of spatial features and attributes, and the encoding method. The logical superstructure provides specifications for the organization and structure of digital spatial data transfer. The list of features and attributes include definitions for those features and attributes. The data transfer encoding method is ISO 8211, an international media-independent interchange format.

Content or Minimum Performance Standards specifies a minimum content or level of quality that a map database must meet for a particular purpose. Since different applications have substantially different performance requirements, one set of content standards developed for a specific requirements are generally not applicable to other applications. Therefore, content standards must be carefully tailored for specific and well-defined applications.

Standard Nationwide Database is the approach of the Japan Digital Road Map Association. With a standard nationwide database, transfer of information from one system to another is relatively simple. On the other hand, a standard nationwide map database is very expensive to create and maintain. This approach is unlikely to be applied in the U.S. because privately created map databases are already widely available.

7.5.3 Reference/Coordinate System for Diaital Map Database

Basic reference/coordinate system requirements for the digital map databases are defined as follows:

+ The map represented by the database is a two-dimensional topological model composed of nodes (e.g., points for intersections, vertices for roadway end-points, etc.) and links (arcs for boundaries, line segments for roadway segments, etc.) imbedded in a planar surface. In this case, the two-dimensional surface is an ellipsoid representing the earth's surface.

+ Geodetic coordinates (geographic reference points whose precise location is well-known and generally agreed upon) and the ellipsoid conform to the specifications of WGS-84, the 1984 World Geodetic System. WGS-84 is the basis for specifying coordinates using the U.S. government's satellite-based global positioning system (GPS) and has rapidly become the accepted standard for applications which involve identifying precise locations on the earth surface.

7.5.4 Data Requirements of Diaital Map Database for TIS Applications

As discussed in the previous sections, data requirements for a digital map database are difficult to specify if the application is not well-defined. This subsection will define the data requirements for the digital map database for the purposes of TIS applications, in particular, in-vehicle navigation.

A navigable database shall consist of both basic elements and optional features. Optional features can be superimposed upon the database as additional layers to meet the requirements of specific applications. The basic database elements include:

+ Topological features, including accurate and current road geometry for map display and map matching purposes. Accurate geometry can be defined as roadways digitized to within 15 meters or less of their ground truth.

+ Physical and functional road classifications. Physical classification is based on a roadway segment's physical attributes, such as a fully-access or restricted access highway and speed limits. Functional classification indicates how the roadway is used to move traffic from one place to another, such as roadway capacities.

+ Addressability, the ability to locate and pinpoint any location or address stated within the covered area. This includes street names, range of addresses, individual address, ascension or descension of the addresses based on the direction of travel.

+ Value-added navigation information, including but not limited to street directions, turn restrictions, physical dividers, one-ways time-of-the-day restrictions, flow restricted roadways (e.g., HOV lanes), construction activities (e.g., detour), and signage that indicating entrances and exits of a limited access roadway.

+ points of interest, such as important landmarks, tourist attractions and business listings.

Optional features may include:

+ ZIP codes;

+ jurisdictional boundaries;

+ demographics;

+ cartographic advances to make the map display more attractive and features more recognizable.

8.0 OPPORTUNITIES FOR PUBLIC/PRIVATE PARTNERSHIPS

In Task 6, we identified the strengths and weakness of the public and private sectors in gathering, fusing, and disseminating traveler information (as shown in Table 8-1 and 8-2), and used this analysis to identify opportunities for public/private partnerships, as shown in Table 8-3.

Table 8-1 : Strengths and Weaknesses of the Public Sector in Non-Partnership Traveler Information Operations

	Strengths	*Weaknesses*
Public Sector	**Data gathering** · Infrastructure availability · Detailed traffic data · Detailed transit data · Construction data • Detailed road and travel condition data	**Data gathering** Insufficient resource to cover the entire Corridor-designated road network No data from private transportation service providers (taxi, bus, air) ! No data from private parking facilities
	Data fusion • Integrated transportation management actions and traveler information • Official advisory • Data ownership • Projection of traffic conditions • Historical data maintenance	**Data fusion** • Jurisdictional barriers--difficult to accommodate intercity travel information • Modal barriers-difficult to provide integrated multimodal information • Limited traveler services information (e.g., Yellow Pages) • Difficult to obtain private data sources due tc competition and conflict of interest • New public agency required to integrate data from multiple sources
	Data dissemination • Roadside information delivery devices and infrastructure • Free of charge • Inherent public information credibility	**Data dissemination** • Limited dissemination methods to meet personal and commercial travel needs • Limited response to market needs-beyond scope of traditional responsibility • Limited or no revenue generation capabilities to recover costs of providing service

Table 8-2: Strengths and Weaknesses of Private Sector in Non-Partnership Traveler Information Operations

	Strengths	*Weaknesses*
Private sector	**Data gathering** . Seamless jurisdictional boundaries . Market driven technological advances . Market-driven implementation and growth	**Data gathering** . Limited to "observable" data on roads . No public transportation system operational status data . Unprofitable markets may be excluded
	Data fusion . Ability to fuse multiple jurisdictions' data and multiple modes' data · Value-added information · Coupling with non-travel services	**Data fusion** . No official traveler advisory information · Decoupled with traffic management actions . Perception of using public funds in private operations
	Data dissemination · Tailored information to meet various user needs · Market-driven dissemination technologies · Market-driven performance and credibility	**Data dissemination** . Basic and free-of-charge services may be dropped-equity issue . Insufficient infrastructure to serve *en route* users who have no in-vehicle equipment

Table 8-3: Potential public/private partnership opportunities in Corridor traveler information services

Information service category	*Areas of potential partnerships*		
	data gathering	*data fusion*	*data dissemination*
1. Real-time incident/congestion summaries	High potential	High potential	Limited potential
2. Construction summaries	Public only	High potential	Limited potential
3. Real-time link status	High potential	High potential	Private only
4. Parking locations	Public only or private only	Public only or private only	High potential
5. Parking availability	High potential	High potential	High potential
6. Road weather conditions	Public only	High potential	Limited potential
7. Traveler advisories	Public only	High potential	Limited potential
8. Alternate routes	Private only[1]	High potential	Limited potential
9. Trip planning capability	Private only[1]	Private only[1]	Private only
10. Route guidance information	Private only[1]	Private only[1]	Private only
11. Road environmental conditions	Public only	Public only	Limited potential
12. Schedule, route, and fare information on all transit modes (bus, rail, air, and ferry)	Public only	Public only	High potential
13. Real-time status information on transit modes (bus, rail, air, and ferry)	Public only	High potential	High potential
14. Paratransit services	Public only	Public only	High potential
15. Ride-matching services	Public only	Public only	High potential
16. Traveler Accommodation Information	Private only	Private only	Limited potential
17. Emergency Assistance Information	Private only	Private only	Limited potential
18. Tourist Attraction Information	Private only	Private only	High potential

[1]Partnership needs to be established in supporting service(e.g., "real-time incident/congestion summaries" and "construction summaries") but not in this particular service.

8.1 INSTITUTIONAL SCENARIOS FOR CTIS

We also developed a set of scenarios for how the Corridor-wide Traveler Information System could be organized institutionally. It is important to understand that the scenarios presented in this section represent the fundamental structure for potential partnerships. It is highly likely that these scenarios will be combined to support the eventual implementation of the Corridor's partnerships.

Scenario l-Corridor-wide traveler information service provided through a single public/private partnership. This scenario would involve the collection (from traffic operations centers, transit properties, etc.), management, fusion, and dissemination of information by a single partner (or team) for the entire Corridor.

The private partner would be responsible for collecting existing data from current and future public and private surveillance installations throughout the Corridor; adding supplementary sources of data collection where necessary: fusing the data into an integrated, accessible database; and disseminating the data to various end users.

The private partner would either directly disseminate or contract with other private firms to disseminate traveler information through various channels-such as pagers, commercial radio, kiosks, and telephone.

Scenario 2-Corridor-wide Traveler Information System management provided by the Corridor Coalition; dissemination to end users provided through public/private partnerships. This scenario would invest the collection and fusion of the data in the public sector and provide for dissemination of the already fused data through private sector partners. This option would provide the l-95 Corridor Coalition with continued control of the information database, but would require investment on the Coalition's part in designing a data fusion system that would have the capacity to serve an unlimited number of private sector partners who would seek access to the fused data.

Scenario 3-The creation of a few to several public/private partnerships on a regional basis to collect, manage, and disseminate traveler information within their respective regions. This approach would identify four or five regions within the I-95 Corridor from Maine to Virginia (e.g., Boston, New York, Philadelphia, Baltimore-Washington, and Richmond), and seek one public/private partnership for each region.

The private sector would be responsible for data gathering, data fusion and dissemination in the region for which they are selected. Dissemination could be done through the regional public/private partnership or through public/private partnerships between the regional partnerships and individual disseminators.

8.2 CRITICAL SUCCESS FACTORS

The implementation of an I-95 Corridor-wide Traveler Information System would succeed if:

+ The information it makes available composes a critical mass.
+ The information it collects and makes available spans virtually all jurisdictions.
+ The information it collects and makes available integrates all modes of interest to the end user.
+ It is structured both technically and institutionally so as to offer a multitude of opportunities for entrepreneurial intermediaries (information service providers, value-added resellers, etc.) to provide traveler information to end users.

In addition, for CTIS to be viable over the long term, it must attract enough funding to support its operation, maintenance, and enhancement.

A traveler information service that does not provide enough of the information a traveler wants or needs will languish from lack of use. Although the ideal might be for CTIS to offer all possible information for all locations in the Corridor, the more modest, more practical goal is for CTIS to concentrate on satisfying most requests for information. At some point, “not enough” information-for example, information limited to a single suburban county’s county-owned roads, ignoring both city streets and principal highways and freeways-becomes “enough”-for example, incident and anecdotal congestion reports covering an entire travelshed, together with reliable travel times for the major freeways and transit performance information. At this point, the system has a “critical mass” of information.

8.2.1 Intermodal

Travelers must usually choose their mode before they can find information about incidents, schedules, and routes. Convenient transfers between modes are often unclear. Routes using different modes cannot usually be compared with respect to comfort, time, and cost because this information is not available. A traveler information service that provides routing information that is transparent as to mode, and that could compare the key parameters of several modes for a given origin-destination pair would do much to promote modal shifts.

8.3 ENTREPRENEURIAL OPPORTUNITIES

The vision of CTIS presented in the project’s scope of work and in our working papers depends crucially on the eager participation of private firms. In order to gain this participation, CTIS will have to be structured to allow, enable, and facilitate an entrepreneur with an idea to get the information he or she needs in a form he or she can adapt. This structure is both technical and institutional. On the technical side, CTIS’ databases and interfaces must make it straightforward to look at and get information. On the institutional side, new, entrepreneurial ideas must not be impeded by excessive, risk-averse bureaucracy or monopoly-seeking contractors.

8.4 FUNDING

CTIS may be funded in two streams: from commercial success, and from the public sector in pursuit of the public good.

On the commercial side, CTIS seeks a “user pay” regime, where end users value the information so highly that they (or intermediaries, such as commercial radio stations) pay for it. In the long run-our Phase II I or beyond-CTIS might receive all of its funding from commercial revenues.

On the public side, CTIS will start out getting much of its funding from public sources. In the long term, if public funding is needed, CTIS must support and be seen to support public-policy goals-not just the “surface” goals of, for example, improving utilization of existing roadways, improving clearance of incidents, but also the fundamental goals of shifting travelers from high-social-cost modes, such as private automobiles, to other modes.

9.0 CONCLUSION AND RECOMMENDATIONS

The objective of Project No. 8, as stated in the I-95 Corridor Coalition Business Plan, is to "provide traveler information to the Corridor Transportation user in a timely and cost effective manner for pre-trip and real-time planning purposes." Following this mandate, we have executed this study-with the guidance of the Technical Review Committee-to accomplish this objective.

Listed below are the conclusions we have drawn from the several tasks performed during the course of this assignment. This chapter then closes with a section containing our recommendations for I-95 Corridor Coalition actions to accomplish the objective of providing traveler information throughout the Corridor.

9.1 TASK 1. INVENTORY OF TIS AND COMMERCIAL OPPORTUNITIES

+ The most widely used TIS dissemination devices in the I-95 Corridor are telephones, variable message signs and highway advisory radio;

+ The most widely deployed TIS services in the Corridor include construction summaries, real-time incident congestion summaries, road and weather conditions and traveler advisories.

+ Four distinct "business sectors" have an interest in TIS availability in the I-95 Corridor: electronic communication companies; information service providers; hardware and software providers; and commercial transportation providers.

+ Several challenges and issues face the development of a TIS, including:

  - readiness of consumer market to accept TIS;

  - multiple jurisdictions involved in collecting and dissemination data;

  - inexperience in fashioning public/private partnerships;

- potential conflict of public policy objectives and private profit motives; and
- information ownership issues.

+ Both the public and private sectors view TIS as a candidate for public/private partnerships, with differing views on problems to be addressed and benefits to be realized.

9.2 TASK 2. DEFINITION OF GOALS FOR THE I-95 CORRIDOR TIS SYSTEM

This task defined candidate goals and objectives for the I-95 Corridor-wide TIS system that are consistent with, among other things, the l-95 Corridor Business Plan and the National ITS Program Plan, The goals have captured the aims, intentions, and aspirations of the ultimate TIS system as defined by Coalition members. In addition, because goals are starting points for requirements, and requirements are starting points for system design, emphasis was placed on developing a clear, concise, realistic and complete set of goals and objectives. Finally, because it is anticipated that the private sector will play a substantial role in the development and operation of TIS, their needs have been incorporated into the TIS goals.

In summary, the major goals to be achieved by the TIS system are the following:

+ Enhance urban and inter-urban corridor road travel for business travelers, tourists, pleasure travelers, commuters, CVO/dispatchers, and transit/paratransit operators.

+ Improve Corridor environmental air quality.

+ Enhance modal and intermodal travel for all urban and inter-city mass transit users.

+ Promote TIS and induce its use to demonstrate to the public the benefits of using ATIS.

+ Enhance the safety of travelers.

+ Encourage private sector participation in the design, development, operations, maintenance, and evolution of the system to ensure TIS success.

9.3 TASK 3. REQUIREMENTS ANALYSIS REPORT

The Traveler Information System will evolve over a period of time, perhaps in three phases described as follows:

+ Phase I of CTIS (0-2 years) is focused on rapidly deployable, baseline information dissemination to the broadest possible public at little or no charge. In addition, through its comprehensive data collection system and database management, the Phase I system is capable of rapid communication about incidents and traffic and transit trends to all affected public agencies, playing a critical role in enhanced incident management. Distinguishing characteristics of the Phase I system are:

    · Baseline information Dissemination:

        - Designed to accomplish near-term public policy objectives by reducing congestion and vehicle emissions, increasing mobility, and enhancing public safety;

        - Designed to build confidence in potential users and public policy decision makers;

        - Based on proven, tested and evaluated technologies --there is no room for experimentation;

        - Designed to modify traveler behavior so that they learn to use traveler information systems in general, CTIS in particular;

- Probably relies heavily on telephony (both wireline and cellular), as the telephone remains the most ubiquitous communications medium with a real-+ Phase II of the Corridor TIS (2 to 5 years) looks significantly different to the end user. Induced in part by the widespread dissemination and utilization of baseline information in Phase I, more sophisticated private sector information dissemination media proliferates. Trained by the public sector's aggressive promotion of the baseline system in Phase

I, the traveling public sees increasing value in the purchase and use of more sophisticated traveler information services, delivered over private media at the expense of either the individual consumer or the wholesaler (such as paging companies or cable TV operators) who see their media enhanced by the delivery of advanced traveler information. The individual traveler end user begins to see in Phase II the availability of interactive multimedia traveler information services over telephone, TV, on-line services, personal digital assistants, (PDAs), etc. In addition to the baseline information disseminated in Phase I, Phase II begins to see new, more sophisticated kinds of information, including predictions and estimation of traffic conditions; traffic demand patterns and trends: detailed, dynamic trip planning and routing information and guidance: and dynamic multimodal trip planning and connectivity. We expect that these new multimedia, interactive information dissemination media offered by the private sector to individual travelers and fleet operators will make extensive use of the traveler information database maintained by the CTIS, perhaps at a fee, which could reduce the level of public subsidy. In addition, dispatchers and fleet managers will begin to be able to make use of similar interactive multimedia information dissemination devices serviced by CTIS.

+ In Phase III (6-l 0 years) heavy emphasis in CTIS shifts to widespread deployment of in-vehicle navigational devices displaying real-time, multimodal navigational information. Such in-vehicle devices likely also serve a mobile probes, recording real-time traffic conditions on an anonymous basis back to CTIS, providing CTIS (which also services real-time, on-road dissemination media such as variable message signs and highway advisory radio) with largely automated, quantitative real-time data. Optimal pre-trip planning, which has the ability to have maximum impact on route, time, and mode of travel, is serviced through increasingly sophisticated multimedia interactive devices in the home or office. But the preponderance of consumer expenditures and commercial vehicle en user expenditures will flow to in-vehicle navigational devices and their servicing with real-time information.

The top level requirements driving the conceptual design are:

+ The CTIS communications system needs to be robust enough to move data from center to center and to get timely and accurate traveler information to all types of pre-trip and enroute users;

+ The CTIS database needs to fulfill the following requirements:

- The CTIS database shall support operations within a distributed, heterogeneous environment which will provide seamless collection and delivery of traffic an other travel information across jurisdictional and modal boundaries:

- Because of the expected level of utilization and the distribution of CTIS facilities throughout the Corridor, the CTIS database shall provide access to multiple, simultaneous users/applications;

- The CTIS database will interface with the Information Exchange Network (IEN) for the receipt/disssemination of data to/from corridor Traffic Operations Centers including local TOCs/TMCs, regional TOS/ATMS, and other future systems to be integrated with the IEN;

- The CTIS database shall provide both direct access and application program interface access, and shall support predefined ("canned") and ad hoc queries. In addition, predefined ("canned") and ad hoc reports will also be supported. It is imperative that the user interface be intuitive and simple to use.

- The CTIS database shall comply with industry standard Data Definition Language (DDL) and Data Manipulation Language (DML). An industry standard such as ANSI SQL will be utilized for DDL and DML development. Subsequent enhancements to the system by either the private or public sector will utilize this same requirement in order to easily integrate with the existing system.

- The CTIS database shall maintain the integrity of the data, including data element format checks (data type, field lengths, etc.), referential integrity between database structures, and valid value constraints (set membership and numeric/data range checking.

- The CTIS database shall provide access control to the database and its functions. Access control includes the ability to add users and customize database privileges based on users and use groups/responsibilities.

- The CTIS database shall provide dictionary facilities for defining, maintaining, and updating TMS database structures. Capabilities supported will include the ability to add new structures, modify existing structures, and delete structures. Robust maintenance and performance features include the capability to store database files and structures across multiple disk volumes will also be provided.

- The CTIS database shall provide automatic and procedural backup of data. These capabilities will insure data integrity in the event of a system (hardware or software) failure. The database shall also provide automatic and procedural recovery of the CTIS data following a system failure.

The database for the CTIS should be a commercial, off-the-shelf relational database management system, due to its more mature technology and established standards.

9.4 TASK 4. EVALUATION OF AVAILABLE TIS TECHNOLOGY

Evaluation of potential end user devices as summarized in Table 9-1.

Table 9-1. End-User Device Technology Evaluation

Device	Priority 1 Accessibility	Priority 2 Ability to Meet User Needs	Priority 3 Interactivity	Priority 4 Cost of Implementation	Priority 5 Cost to User	Priority 6 Ease of Use
Radio	High	Medium	Low	High	High	High
Television	High	Medium	Low (unless interactive)	Medium	High	High
Telephone	High	High	High	Medium	High	High
Pagers	Medium	Medium	Low	Medium	High	High
In-Vehicle Devices	Low	High	High	Low	Low	Medium
Kiosks	Medium	High	High	High	Medium	High
Computers and PDAs	Medium	High	High	High	Medium	Medium
Faxing	Medium	High	Low	High	Medium	High
VMS	Medium	Medium	Low	High	High	High

High = meets all criteria Medium - partially meets criteria Low = does not meet criteria

9.5 TASK 5. SYSTEM CONCEPTUAL DESIGN

The system design will be a distributed architecture, made up of possibly 5 Regional Traveler Information Centers (RTICs) serving the Corridor's major travelsheds. Potential RTICs may be:

- Boston (including Hartford, Providence, and northern New England).
- New York (including southern Connecticut, northern New Jersey, and northeastern Pennsylvania).
- Philadelphia (including Camden, Chester, Wilmington, and central and southern New Jersey).
- Baltimore-Washington (including northern Virginia).
- Richmond Norfolk.

Each RTIC must be able to communicate with and be compatible data-wise with each other RTIC, and must therefore adhere to technological and business practices standards.

Each RTIC may evolve differently from a public/private function perspective, depending upon the entities involved in each geographic area.

9.6 TASK 6. PUBLIC/PRIVATE PARTNERSHIP OPPORTUNITIES

Based on the Task 6 analysis and the input of various potential private sector partners surveyed for this task, Scenario 3 -- a series of regional public/private partnerships, employing a request for partnerships proposal (RFPP) -- is the preferred approach to accomplishing a public/private partnership for delivery of traveler information services in the I-95 Corridor.

The reasons for this preference include the following:

+ Speed of deployment: This approach will allow the public sector to implement quickly a procurement for regional traveler information systems. Some of the factors in reaching this conclusion include:

  · the relative simplicity of preparing and RFPP;

  · the existing regional relationships among transportation departments and other transportation authorities (e.g. TRANSCOM); and

  · the ability of potential private sector partners to respond more quickly to a regional rather than a Corridor-wide system.

+ Manageability of process: Dividing the Corridor into regional, logically consistent segments improves the manageability of the procurement process for both the public and private sectors. The use of the RFPP procurement method removes the need for the public sector to prepare detailed specifications for the system. Both of these factors simplify the management of the procurement process.

+ Wide range of potential private partners: A regional RFPP approach represents a more open and competitive procurement process than some other options. Regional as well as national companies will be brought into the process, thus increasing the pool of talent and creative proposals.

9.6 PROJECT TEAM RECOMMENDATIONS

Based upon the conclusions of Tasks 1-6 of this study, and the input of the Project 8 Technical Review Committee and the Coalition's Public/Private Partnership Task Force, we recommend the Coalition take the following steps to advance the implementation of a Traveler Information System for the I-95 Corridor.

9.3.1 Field Operational Test

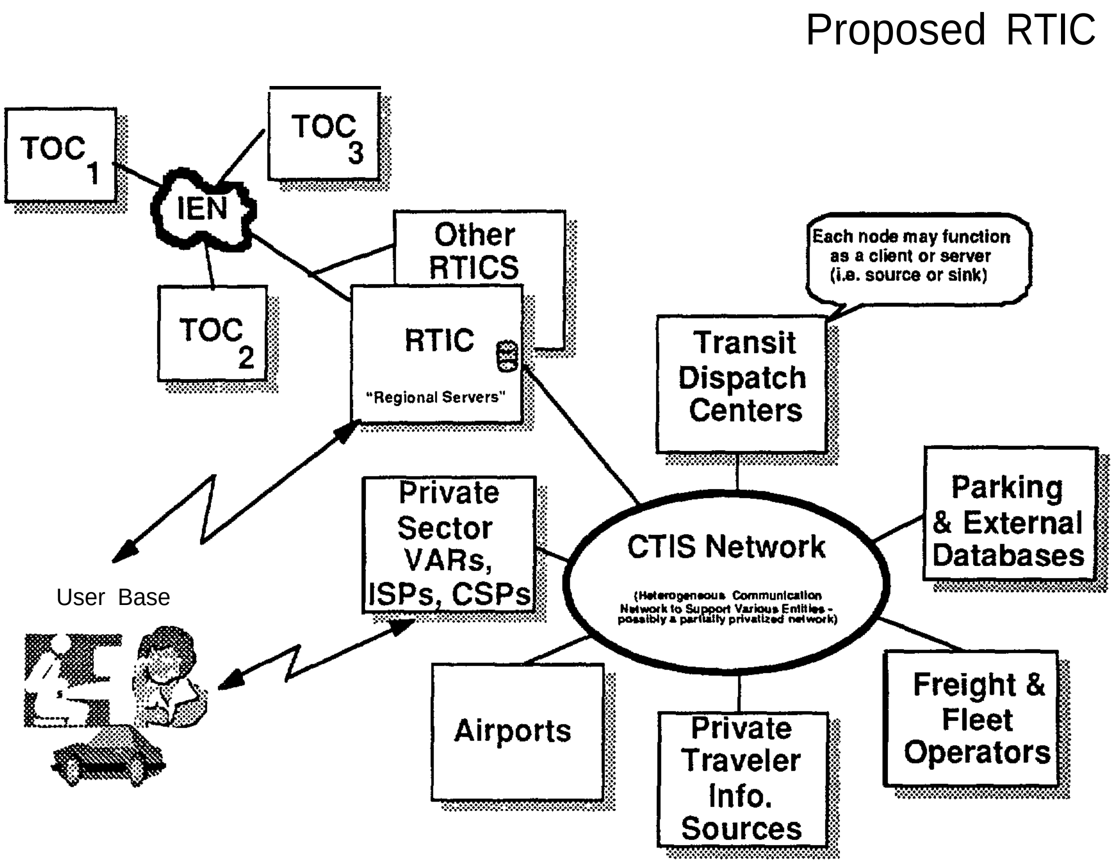
The first step is to establish a Field Operational Test of one or more Regional Traveler Information Centers as described in Task 5 of the report. The following is an overview of the FOT.

The proposed Field Operational Test is for the development of a pair of Regional Traveler Information Centers to support the I-95 Corridor's concept of inter-regional traveler information. The proposed RTIC would fit into the Coalition's overall model that calls for four regional clearinghouses/servers. This inter-regional concept is novel and has not been attempted in the U.S. The specific location of the RTICs will be chosen based on the Coalitions preferences as well as the ability and willingness of an existing TOC to host the operation. Candidate regional sites mirror those of the proposed "regional servers".

The proposed RTICs, depicted in Figure 1, is a public-private partnership aimed at providing travelers in the congested I-95 Corridor with enhanced, actionable, real-time, multi-modal traveler information used for making informed travel decisions. The RTICs, using an open architecture and standard DBMS technology, will provide a testbed for the private-sector to provide or obtain traveler information and to experiment with various types of dissemination channels and devices.

The proposed RTIC ,design would take advantage of FHWA sponsored ATMS Support System work by utilizing existing data management (i.e. DBMS) and inter-TMC/TOC data exchange software. This software is used both to manage data within a single TMC/TOC and to exchange, in real-time, data between TMCs. Additionally, support is provided for the management of a regional traffic database, that has local access to data acquired from multiple remote sites. These existing FHWA/Loral modules focus on managing and distributing both asynchronous and synchronous data. Synchronous data includes real-time, link-based data (speed, volume, occupancy, surface condition) and control data (signal plans, VMS/HAR messages). Asynchronous data includes incident data (accidents, construction events, special event plans).

Figure 9-i. FOT System Architecture



The proposed FHWA/Loral software will be used for the following:

+ Development of a regional database that integrates surveillance data from public agencies with that available from private sources, such as Metro Traffic Networks or Shadow Broadcast Services

+ Replication of information contained in the regional database with other regional nodes (e.g., TRANSCOM) or selected local sites (e.g. Philadelphia or NYC TOCs).

+ Integration with the Information Exchange Network to provide the backbone to "link-up" with other public agency centers.

Implementation of the RTIC will utilize a phased approach to take advantage of data sources/sinks, dissemination technologies and private-sector participants as they become available. The following identifies each of these areas:

+ Data Sources/Sinks:

  - TMCs/TOCs/Regional ATMS/RTICs
  - Transit Dispatch (Bus, Rail, Subway)
  - Airports
  - Ferry Operations
  - Commercial Traffic Reporting Firms
  - Private Parking Garage Firms
  - Private Weather Data Firms
  - Private Environmental Firms
  - Commercial Vehicle/Fleet Operators

+ Dissemination Technologies to be Evaluated:

  - VMS/HAR
  - Traditional TV
  - Traditional Radio
  - Cable TV
  - Interactive TV
  - High-Speed FM Subcarriers/CDPD/RBDS using ITIS BIF/BAP standards

- Automated Paging (including new 2-way communications)
- Automated Faxes
- In-Vehicle Devices
- Hand-Helds (PCSs, PDAs)
- On-Line ISPs (AOL, Prodigy, CompuServe, Delphi)
- Internet (WWW/Mosaic, e-mail)
- Kiosks (Rest Stops, Employment Centers, Tourist Areas, Malls)

+ Initial Candidate Private-Partners:

  - Metro/Shadow
  - Discover America
  - SmartRoute Systems
  - Seiko Telecommunication Technologies
  - AOL
  - Motorola
  - A T & T

+ Pre-Trip and Enroute Traveler Information Services:

  - Real-Time Incidents/Congestion
  - Construction/Special Event Reports
  - Travel Advisories

- Link-Data
- Real-Time Transit Information
- Static Traffic Data (including road restrictions, road topologies, etc.)
- Static Transit Information
- Weather and Environmental Reports
- Traffic Forecasts, demands, and trends
- Trip Planning (including route-guidance, parking, alternate routes/modes, travel time comparisons)
- Emergency Services
- Yellow Pages
- Ride-Matching

9.3.2 Public Private Partnership Forum

Sponsor a Public/Private Partnership forum for a presentation and discussion of the findings of Task 6 of this report as they relate to the model and procurement methods recommended for implementation of a Public/Private Partnership of I-95 Traveler Information Services.

Project 8
Task 1 – Traveler Information Services (TIS)
Inventory of Traveler Information Services and Commercial Opportunities in the I-95 Corridor

Project 8
Task 2 – Traveler Information Services (TIS)
A Definitions of Goals for the I-95 Corridor TIS System

Project 8
Task 3 – Traveler Information Services (TIS)
Requirements Analysis Report

Project 8
Task 4 – Traveler Information Services (TIS)
Evaluation of available TIS Technology

Project 8
Task 5 – Traveler Information Services (TIS)
TIS Conceptual Design

Project 8
Task 6 – Traveler Information Services (TIS)
Scenarios for Private Sector/Partnership TIS Opportunities

APPENDIX C
Public Agency Survey Results